NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

Vol. X. March, 1896. No. 3.

This Association, as a body, is not responsible for the statements or opinions of any of its members.

QUARTERLY MEETING.

YOUNG'S HOTEL, BOSTON, MASS., Dec. 11th, 1895.

The following members and guests were present, Vice-President Charles K. Walker of Manchester, N. H., presiding:

MEMBERS.

E. L. Abbott, Boston, Mass.; C. H. Baldwin, Boston, Mass.; G. E. Batchelder, Worcester, Mass.; Joseph E. Beals, Middleboro, Mass.; J. F. Bigelow, Marlboro, Mass.; Dexter Brackett, Boston, Mass.; Henry Chandler, Manchester, N. H., Geo. F. Chace, Taunton, Mass.; John C. Chase, Wilmington, N. C.; Harry W. Clark, Lawrence, Mass.; Freeman C. Coffin, Boston, Mass.; R. C. P. Coggeshall, New Bedford, Mass.; H. W. Conant, Gardner, Mass.: Byron I. Cook, Woonsocket, R. I.; Henry A. Cook, Salem, Mass.; F. H. Crandall, Burlington, Vt.; Geo. K. Crandall, New London, Conn.; Geo. E. Crowell, Brattleboro, Vt.; L. E. Daboll, New London, Conn.; Francis W. Dean, Boston, Mass.; John W. Ellis, Woonsocket, R. I.; B. R. Felton, Marlboro, Mass.; F. F. Forbes, Brookline, Mass.; Richard J. Flinn, Brookline, Mass.; Frank L. Fuller, Boston, Mass.; Julius C. Gilbert, Whitman, Mass.; D. H. Gilderson, Bradford, Mass.; Fred B. Gleason, Marlboro, Mass.; E. H. Gowing, Boston, Mass.; E. A. W. Hammatt, Boston, Mass.; Geo. W. Harrington, Wakefield, Mass.; John C. Haskell, Lynn, Mass.; L. M. Hastings, Cambridge, Mass.; V. C. Hastings, Concord, N. H.; William E. Hawks, Bennington, Vt.; Allen Hazen, Boston, Mass.; Horace G. Holden, Nashua, N. H.; Daniel D. Jackson, Newton, Mass.; Willard Kent, Woonsocket, R. I.; Patrick Kieran, Fall River, Mass.; James W. Locke, Brockton, Mass.; T. H. Mackenzie, Southington, Conn.; Wm. McNally, Marlboro, Mass.; James W. Morse, Natick, Mass.; H. H. Nash, Jr., Boston, Mass.; F. L. Northrop, Milford, Mass.; F. G. Perry, Pawtucket, R. I.; W. H. Richards, New London, Conn.; G. J. Ries, Weymouth Centre, Mass.; W. W. Robertson, Fall River, Mass.; H. W. Rogers, Haverhill, Mass.; A. H. Salisbury, Lawrence, Mass.; Sidney Smith, Rutland, Vt.; F. H. Shepard, Derry, N. H.; G. A. Stacy, Marlboro, Mass.; Chas. H. Swan, Boston, Mass.; Lucian A. Taylor, Boston, Mass.; Robert J. Thomas, Lowell, Mass.; Wm. H. Thomas, Hingham, Mass.; W. H. Vaughn, Wellesley Hills, Mass.;

C. K. Walker, Manchester, N. H.; Joseph Watters, Fall River, Mass.; G. C. Whipple, Brighton, Mass.; J. C. Whitney, West Newton, Mass.; Geo. E. Winslow, Waltham, Mass.; E. T. Wiswall, West Newton, Mass.; W. G. Zick, New York City.; Morris Knowles, Boston, Mass.; E. R. Jones, Boston, Mass.; *Engineering Record*, New York City, by C. J. Underwood, Jr.; Chapman Valve Manufacturing Co., Indian Orchard, Mass., by E. L. Ross; Hersey Manufacturing Co., South Boston, Mass., by Samuel Harrison; Henry F. Jenks, Pawtucket, R. I.; McNeal Pipe and Foundry Co., Burlington, N. J., by Wilmer Reed; National Meter Co., New York City, by J. G. Lufkin; Neptune Meter Co., New York City, by W. G. Zick; Peet Valve Co., Boston, Mass., by Secretary Russell and S. B. Adams; Thomson Meter Co., Brooklyn, N. Y., by E. L. Abbott; Union Water Meter Co., Worcester, Mass., by J. P. K. Otis and Geo. H. Carr; Walworth Manufacturing Co., Boston, Mass., by J. H. Eustis; H. R. Worthington, South Brooklyn, N. Y., by J. M. Betton and Geo. B. Ferguson.

GUESTS.

Gerald Bliss, Walpole, Mass.; M. N. Boardman, Georgetown, Mass.; Arthur N. Cram, Water Commissioner, Walpole, Mass.; J. W. Crawford, Secretary Water Board, Lowell, Mass.; Allston H. Evans, Water Commissioner, Medford, Mass.; William L. Hills, Water Commissioner, Lowell, Mass., Stephen H. Jones, Water Commissioner, Lowell, Mass.; J. J. Moore, Contractor, Boston, Mass.; A. D. Negus, Pumping Engineer, New Bedford, Mass.; Henry P. Plimpton, Chairman Water Board, Walpole, Mass.; Geo. E. Putnam, President Water Board, Lowell, Mass.; Frank L. Weaver, Water Commissioner, Lowell, Mass.

The following new members were elected:

RESIDENT ACTIVE.

E. W. Bailey, Assistant City Engineer, Somerville, Mass.
H. N. Turner, Manager Water Co., St. Johnsbury, Vt.
Arthur Elliott Hatch, Civil Engineer, Providence, R. I.

NON-RESIDENT ACTIVE.

Wm. P. Mason, Professor Polytechnic Institute, Troy, N. Y.
Wm. H. Ashwell, Civil Engineer, Detroit, Mich.

ASSOCIATE.

Mellen S. Harlow, Agent Ingersoll-Sergeant Drill Co., manufacturers Pohle Air Lift Pump, Boston, Mass.

Lester E. Wood, Eastern Sales Agent Anniston Pipe and Foundry Co., and Chattanooga Foundry and Pipe Works.

Mr. Dean of Boston read a paper prepared by Mr. Charles A. Hague of New York on "Operation of a Pumping Plant by Electricity," and also a discussion of the paper which had been presented by Mr. George H. Barrus of Boston. The paper was also discussed by Mr. Dean himself.

COATING OF CAST IRON PIPE.

MR. WALKER. If there is to be no further discussion of Mr. Hague's paper, I would like to ask for a little information as to why it is that cast iron pipe is not coated as well as it was some years ago. I would like to know whether it is because the coating cannot now be obtained, or whether there is some other reason. The pipe should be dipped in tar, and I would willingly pay two or three dollars more a ton for it than for the painted pipe that we usually get now.

AN ASSOCIATE MEMBER stated in reply to Mr. Walker's question, that there was a concern in Philadelphia that had a monoply of the coal tar production, and that it is difficult at times to get distilled tar for coating pipes, and that when it is impossible to get tar which has had the naphtha removed from it by distillation, it is necessary to purchase what can be obtained on the market. He further stated that some of the pipe manufacturers are considering the matter of putting in plants to distill their own tar, and he thought that the day was not far distant when they would be independent and would distill their own tar from the product obtained from the gas works. He further stated that he thought that skilful laborers could apply the crude tar in such a way as to produce almost as good a coating as that obtained with the use of distilled tar.

THE USE OF WATER FROM HYDRANTS.

MR. WALKER. I am very glad to have heard from the gentleman and to learn some of the facts of the case. I didn't come here to be president today, but to ask questions, and I want to know if any of the superintendents here present have had anything to do with skating rinks? Up in Manchester they have a custom of flooding the common and other convenient land. To do this they draw the water from the hydrants, and because the water is not properly shut off, frozen hydrants are usually the result, and there is nothing that a fireman likes to talk about so much as a frozen hydrant. I think it would be better to have a separate pipe put in for the purpose of flooding when it is desired, and I would like to know what the rest of you do in similar cases, so that I could tell my people about it; for when a man has been superintendent as long as I have been, it does make any difference what he says, he is called an old crank anyway. I tell our fire department when they find a

frozen hydrant to go to the next one. They are only 250 feet apart, and when they find one frozen all they have to do is to hitch on more hose and go 250 feet farther. That seems easy enough, but still I suppose it won't do.

There is another thing that troubles me, and that is the public watering troughs. The people most interested in having the troughs put in (for the benefit of the public of course) are the stable keepers, and they want them convenient to their stables. They put meters on the services in their houses and stables, and you cannot charge them for the water used in watering their horses, because they drive them up to that trough every night and morning. Now, if anyone can tell me how to get even with such a fellow I should be much obliged.

MR. CHASE. I am a firm believer in the idea that fire hydrants should be invariably reserved for the use for which they were intended, that is, for extinguishing fires, and that they should only be used by the department.

MR. HASKELL. I don't know what the city ordinances are in Manchester, but I think it would take a good deal of responsibility from the superintendent if the firemen were given the control of the hydrants, and if they were held to the exercise of proper supervision over them, as they are in Lynn. In my city nobody except firemen and the superintendent of the water works has any authority to touch a hydrant. The firemen are held responsible if a hydrant is out of order, unless they may have sent word to the superintendent that there was trouble and they wanted repairs made. They go around in the fall, and if they find a leaky hydrant, or anything that they think may have a tendency to cause it to freeze, they notify us, and then the responsibility is on our shoulders to fix it so that there is no danger; and there is no time when I have allowed that responsibility to rest on me more than a day without discharging it. I don't care to be burdened with any such responsibility, and I don't propose to be open to criticism in case a hydrant is out of order or frozen.

MR. JONES. As I understand it, an honorary member has no right to speak unless he has permission from the chair, but with your permission I would like to say in regard to hydrants freezing that I think our hydrants as a general thing are not deep enough in the ground. There certainly is a point where they wont freeze. It

wouldn't cost but very little to have the hydrants made considerably longer, and I think that that would save a good deal of trouble. Mr. Walker spoke of having the firemen go to the next hydrant in case the first one was frozen, but it occurs to me that a better plan would be to have the fire in a locality where the hydrants are not frozen. (Laughter.)

MR. CRANDALL. I think that if Mr. Walker would provide a temporary shelter over his hydrant, and attach a meter, and send a man to watch it, and charge the parties requesting the flooding meter rates for the water, as well as for the time of the attendant, that he would find that he would have no further trouble with skating rinks.

MR. THOMAS. We have had more or less trouble from the use of hydrants by persons without authority. About a year ago there was a fire in the residence of a member of our water board, and it was reported that the nearest hydrant was frozen; but upon investigation it was found that the hydrant was not frozen, but that an inexperienced fireman had tried to open it in the wrong way, and, with the aid of a long handled wrench and two or three men, had succeeded in breaking the spindle, and the matter was thus explained. We allow water to be used from hydrants by anyone, but we always send a man to operate them, and then if anything happens we know it and are responsible for it, and the man sees that it is in order before he leaves it. We also examine all hydrants after every fire. Our hydrants are about five feet in the ground and I have never known of one being frozen. The firemen are put through a course of training in handling them and we do not have the trouble we used to have from their carelessness.

MR. WALKER. What do you do in case a man wants to flush out a sewer that is stopped up?

MR. THOMAS. We charge him four dollars and make him pay in advance.

MR. STACEY. In Marlboro we have had a rule ever since we commenced operations that the hydrants were exclusively under the control of the water department, and not even a fireman, except in case of fire, was allowed to touch them without permission from the water department. By starting right in the first place and by sticking to it we have succeeded, up to the present time, in controlling our hydrants, so that the responsibility for their condition rests wholly upon the shoulders of the superintendent, although I have

often got myself disliked by the rigid enforcement of the rule. If a party wants to use the hydrants, and there is a real necessity for it, I send a man and charge the party for the time and for the water. After the first of November the hydrants are not allowed to be used even if permission has been previously granted, except, of course, in case of fire. At the beginning of every winter we inspect our hydrants, and do not wait for them to drain out, but pump them dry. Our department responds to alarms just as if it was itself the fire department, and sees that the hydrants are properly taken care of. We had an application for permission to flood a skating rink, and we told the parties that we would sell the water for 50 cents a thousand and 40 cents an hour for a man to tend the hydrant. After they had figured up the cost they concluded that it would not pay, and we have had no more applications.

I believe that hydrants should be held for the purpose for which they were intended. There will be trouble enough with them in any case, and are always liable to freeze however great care is taken of them. I have known a hydrant to freeze up within twenty-four hours of the time it was inspected, but I have never known one to freeze at the bottom or in the connection. The freezing has always come from the filling up of the post with ground water. We find that we have trouble enough with them taking care of them ourselves and we do not care to trust even the fire department.

ADJOURNED MEETING.

YOUNG'S HOTEL, BOSTON, Jan. 8th, 1896.

The following members and guests were present:

ACTIVE.

E. L. Abbott, Boston, Mass.; Frank A. Andrews, Nashua, N. H; Lewis M. Bancroft, Reading, Mass.; G. E. Batchelder, Worcester, Mass.; J. F. Bigelow, Marlboro, Mass.; George Bowers, Lowell, Mass.; A. W. F. Brown, Fitchburg, Mass; G. A. P. Bucknam, Norwood, Mass.; George F. Chace, Taunton, Mass.; John C. Chase, Wilmington, N. C.; Harry W. Clark, Lawrence, Mass.; R. C. P. Coggeshall, New Bedford, Mass.; Byron I. Cook, Woonsocket, R. I.; B. R. Felton, Boston, Mass.; Desmond FitzGerald, Boston, Mass.; Z. R. Forbes, Brookline, Mass.; Frank L. Fuller, Boston, Mass.; T. C. Gleason, Ware, Mass.;

Albert S. Glover, Boston, Mass.; W. J. Goldthwait, Marblehead, Mass.; J. A. Gould, Boston, Mass.; Richard A. Hale, Lawrence, Mass.; G. W. Harrington, Wakefield, Mass.; John C. Haskell, Lynn, Mass.; Arthur E. Hatch, Providence, R. I.; John S. Hodgson, Wellington, Mass.; Horace G. Holden, Nashua, N. H.; William S. Johnson, Boston, Mass.; George A. Kimball, Boston, Mass.; Horace Kingman, Brockton, Mass.; Morris Knowles, Boston, Mass.; James W. Locke, Brockton, Mass.; Edward C. Nichols, Reading, Mass.; John H. Perkins, Watertown, Mass.; George S. Rice, Boston, Mass.; W. H. Richards, New London, Conn.; G. J. Ries, Weymouth Centre, Mass.; W. W. Robertson, Fall River, Mass.; Harley E. Royce, Brookline, Mass.; A. H. Salisbury, Lawrence, Mass.; William T. Sedgwick, Boston, Mass.; George A. Stacy, Marlboro, Mass.; Lucian A. Taylor, Boston, Mass.; Robert J. Thomas, Lowell, Mass.; William H. Thomas, Hingham, Mass.; W. H. Vaughn, Wellesley Hills, Mass.; C. K. Walker, Manchester, N. H.; J. Alfred Welch, Methuen, Mass.; George C. Whipple, Brookline, Mass.; George E. Winslow, Waltham, Mass.; C. F. Murphy, Marlboro, Mass.; J. C. Whitney, Newton, Mass.; Chadwick Lead Works, Boston, Mass., by A. H. Brodrick; Chapman Valve Manufacturing Co., Indian Orchard, Mass., by E. L. Ross.; Deane Steam Pump Co., Holyoke, Mass., by F. H. Hayes; Hersey Manufacturing Co., Boston, Mass., by Jas. A. Tilden, J. E. Spofford and Samuel Harrison; Ingersoll-Sergeant Co., Boston, Mass., by M. S. Harlow; Ludlow Valve Manufacturing Co., Troy, N. Y., by H. B. Winship; National Meter Co., New York City, by C. H. Baldwin; Peet Valve Co., Boston, Mass., by S. B. Adams; Perrin, Seamans & Co., Boston, Mass., by H. L. Bond; Anthony P. Smith, Newark, N. J., by W. H. Van Winkle; Union Water Meter Co., Worcester, Mass., by J. P. K. Otis; R. D. Wood & Co , Philadelphia, Pa., by Jesse Garrett and A. H. Hoffman; *The Engineering Record*, by C. J. Underwood, Jr.

GUESTS.

M. F. Brennan, Lowell, Mass.; W. R. Copeland, Lawrence, Mass.; J. W. Crawford, Boston, Mass.; Frank S. Hart, Boston, Mass.; S. H. Jones, Lowell, Mass.; M. A. Kimball; Geo. E. Putnam, Lowell, Mass.; Dr. Theobold Smith, Boston, Mass.; Col. W. E. Spaulding, Nashua, N. H.

President FitzGerald on calling the meeting to order, spoke as follows:

Gentlemen of the New England Water Works Association:

This is the first opportunity that I have had of meeting with you since you did me the honor to elect me as your presiding officer. It is perhaps fitting that I should now give expression briefly to a few of the thoughts that are uppermost in my mind. In the first place, I wish to acknowledge my appreciation of the responsibilities of the high office to which I have been elected, and to promise my best efforts to the advancement of the interests of this association. No one can have followed very closely the past history of this body

without recognizing how rapidly it has pushed its way to the front, as one of the leading water works institutions of the country. The New England Water Works Association has not only come to stay but it is going to make its influence felt more and more as time rolls on, in other words, it has a brilliant future awaiting it.

There are two ways in which we may receive the development of this united band of water works officials. We may go on in a conservative way as we have begun, making this society an exchange ground for our ideas and experiences, which was indeed the very corner stone of our foundation. Or we may easily drift into a more formal method of procedure as we expand. For my own part, I believe the latter method would be highly undesirable, and that we should continue for some years to come at any rate, to make these meetings common ground, where the youngest comer to our ranks will be as welcome as the oldest veteran, and where it will be distinctly understood that we come to learn and to have a good time in the learning.

I shall never forget my own indebtedness for valuable ideas in water works construction and management, gathered at various times from the many members who have narrated on this floor in a simple manner, their own experiences. I hope that we shall give an important place in the future as in the past, to the idea of the five minute papers; let us have plenty of them and let no one feel that his own experience is too restricted to be narrated on this floor.

There is one other matter to which I wish to allude before proceeding with the regular order of exercises. We have lately as you know, entered into a mutual arrangement with the Boston Society of Civil Engineers, for the occupancy of headquarters in the new Tremont Temple building. These rooms, I believe under wise management, can be made extremely useful and attractive to the members of both societies. It is my own idea that we should at once begin to form a distinctive water works library. If this plan is entered into with zeal and persistence, it is my belief that in the course of a few years we shall be able to collect here in Boston one of the finest water works libraries in the world. Certainly if you gentlemen enter into this scheme, there is no reason why this cannot be done. For the purpose of starting the matter, in however humble a way, I propose now to give the association the larger part of books and pamphlets on water works subjects that I have collected during the past twenty years. Not that there is any great value attached to

these as a collection, although I believe there are some volumes which could not be duplicated, but I wish to give some visible form to the idea. I have a number of bound volumes of water works reports to which I have always attached more or less importance; if other gentlemen will contribute to the expansion of this collection and to the filling of gaps, and if we can then start a good system for the collection of all water works reports which are issued in the future, this will in itself in the course of time prove of great value to those who are to succeed us in our chosen vocation. But I need not point out the ease with which a library can be collected by the united efforts of our members, nor the advantages which will accrue from a library formed in this way. It seems to me that the matter is one which can be safely left in your hands.

ELECTION OF NEW MEMBERS.

On motion of Mr. Fuller, the secretary cast the ballot of the association for A. O. Doane, assistant engineer in charge of the additional supply for the city of Newton, and for Huber D. Card, city engineer, Willimantic, Conn., applicants for resident active membership, and they were declared elected members.

The President read a communication from Mr. F. A. W. Davis, President of the American Water Works Association, extending an invitation to the members of the New England Water Works Association to be present at the meeting of the American Water Works Association at Indianapolis in May, and he stated that he was anxious to have the New England people largely represented.

On motion of Mr. Holden, a request for a copy of Dr. Smith's paper was referred to the Executive Committee with full powers.

THE PRESIDENT. I suppose there never has been a time, gentlemen, when men were inquiring with so much care and detail into everything connected with water-borne diseases. The fact is, if we are going to be killed by drinking water, we want to know exactly how it is done, and we want to know it from the best possible authority. Dr. Theobold Smith, Pathologist of the Massachusetts State Board of Health, has very kindly come here today to tell us about this subject, and I have the pleasure of introducing him to you now. He will read a paper on "Water-Borne Diseases."

THE WATER SYSTEM OF BURLINGTON, VT.

BY

F. H. CRANDALL, C. E., Superintendent.

[Read September, 1895.]

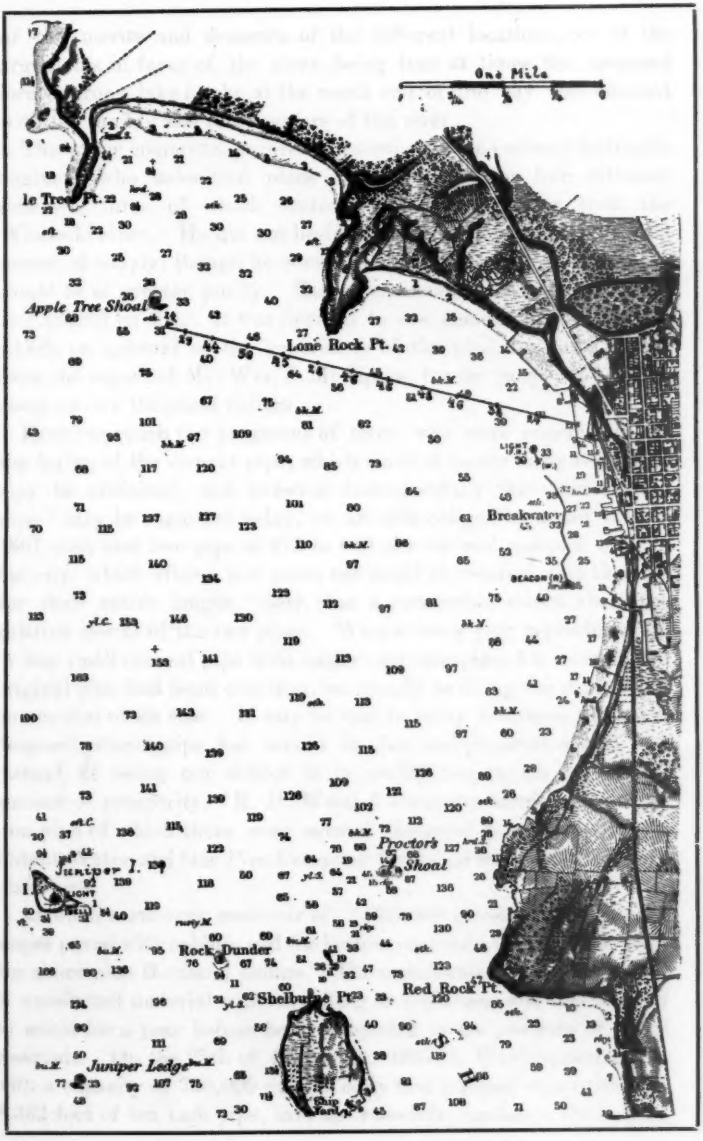
MR. PRESIDENT AND GENTLEMEN: As it has been suggested that a description of the Burlington works would be appropriate, and lest you should undertake to investigate for yourselves and come to an untimely end in the north railroad yard, I will, with your permission, occupy a few moments in their description.

An act to incorporate the City of Burlington passed the legislature in November, 1864, and was accepted at a town meeting held in January, 1865. On the first day of October of the following year the city came into possession, by purchase, of the plant of the Burlington Aqueduct Company, comprising an underground brick reservoir of about 75,000 gallons capacity, several thousand feet of small cast and wrought iron mains and about two hundred lead services. Lead has since given place to galvanized iron as a material for services.

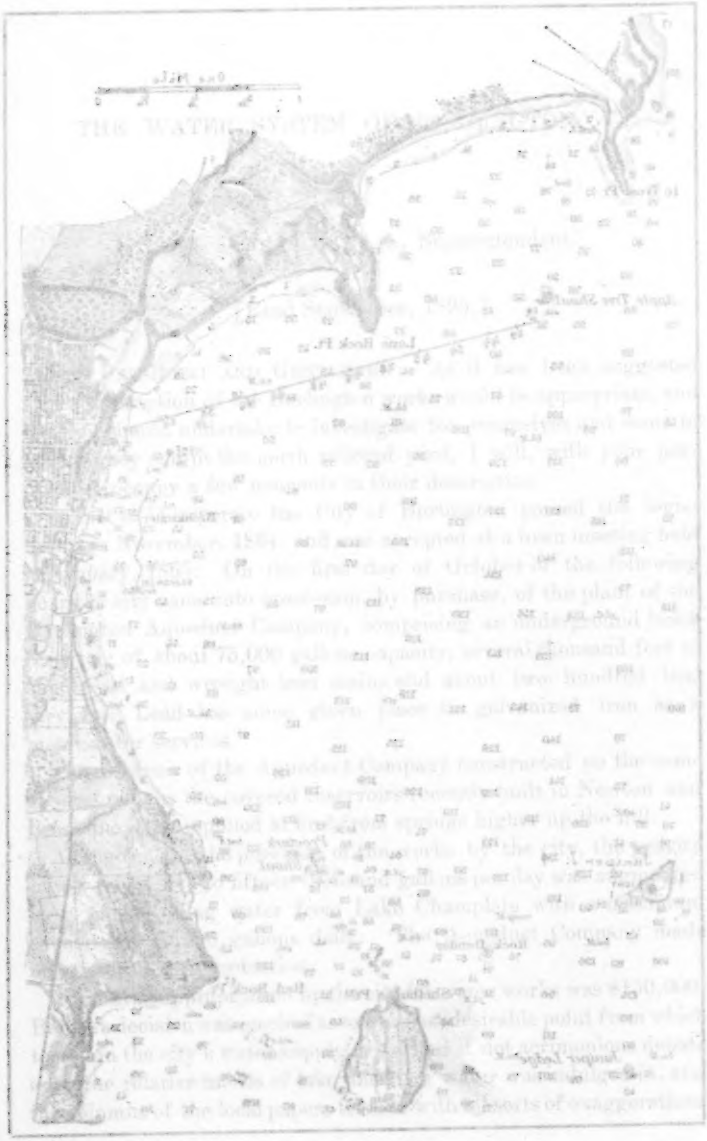
The reservoir of the Aqueduct Company constructed on the same general plan as the covered reservoirs recently built in Newton and Brookline, was supplied at first from springs higher up the hill.

At the time of the purchase of the works by the city, the gravity supply, some five to fifteen thousand gallons per day was augmented by a pump taking water from Lake Champlain with a maximum capacity of 63,000 gallons daily. The Aqueduct Company made no attempt at fire protection.

The initial appropriation by the city for water works was $150,000. Before a decision was reached as to the most desirable point from which to obtain the city's water supply, a spirited if not acrimonious debate as to the relative merits of lake and river water was indulged in, and the columns of the local papers teemed with all sorts of exaggerations



LOCATION OF INTAKE, BURLINGTON HARBOR.

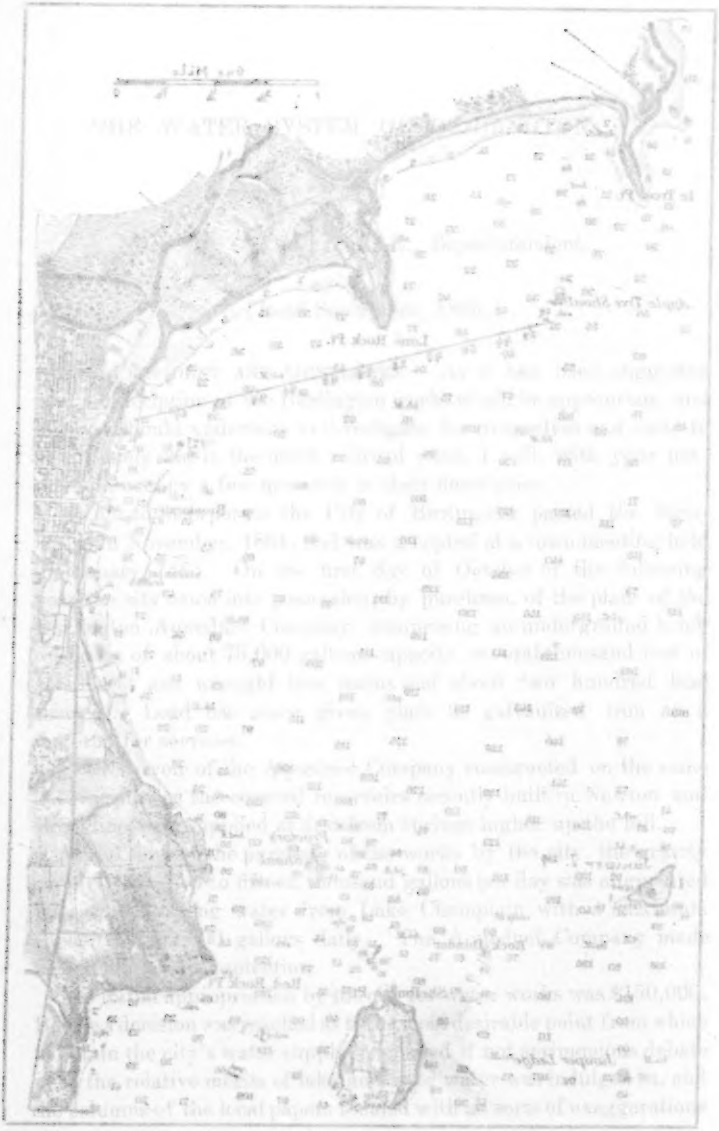

Lone Rock Pt.
Juniper Ledge

of the merits and demerits of the different locations, one of the arguments in favor of the river being that at times the proposed location for a lake intake at the north end of the bay was covered with the muddy and filthy waters of the river.

The water committee secured the services of an eminent hydraulic engineer who submitted plans and estimates for four different schemes, three of which contemplated taking water from the Winooski river. He did not hesitate to recommend the river as a source of supply, though he considered that the water from the lake would be of greater purity. His recommendations were accepted, and placed on file. It was decided to use cement lined pipe, not wholly on account of the superiority of the pipe, but, as I gather from the report of Mr. Wm. J. McAlpine, for the purpose of saving about twelve thousand dollars.

However much the judgment of those who were responsible for the laying of the cement pipe, which many of us are today replacing, may be criticized, and however disrespectfully the "old cement pipe" may be regarded today, we are still obliged to admit that in 1867 with cast iron pipe at $75 to $80 per ton and samples of it in the city, which after a few years use could be crushed with the heel for their entire length, there was a reasonable doubt about the relative merits of the two pipes. We are every year replacing more or less small cement pipe with larger cast iron pipe, but even if the original pipe had been cast iron, we should be doing the same thing on account of its size. It may be that in many instances the much despised cement pipe has served its day and generation well, and instead of being our debtor is in reality responsible for a large amount of prosperity. R. D. Wood & Company furnished the cast iron pipe of which there were several thousand feet used and the Patent Water and Gas Pipe Company furnished and laid the cement lined pipe.

An open earthwork reservoir of 2,236,000 gallons capacity, with slopes paved with cobbles and the bottom covered with sand, was built for about nine thousand dollars. The embankment was constructed of unselected material without rolling or puddling, and was allowed to settle for a year before being subjected to the pressure of a full reservoir. On the 25th of December, 1867, a Worthington pump with a capacity of 750,000 gallons daily first pumped water through 8,362 feet of ten inch pipe, into the reservoir, against a static head



LOCATION OF INTAKE, NEWINGTON HARBOR.

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of 125 pounds. Water is pumped directly into the distributing mains, the surplus going to the reservoir.

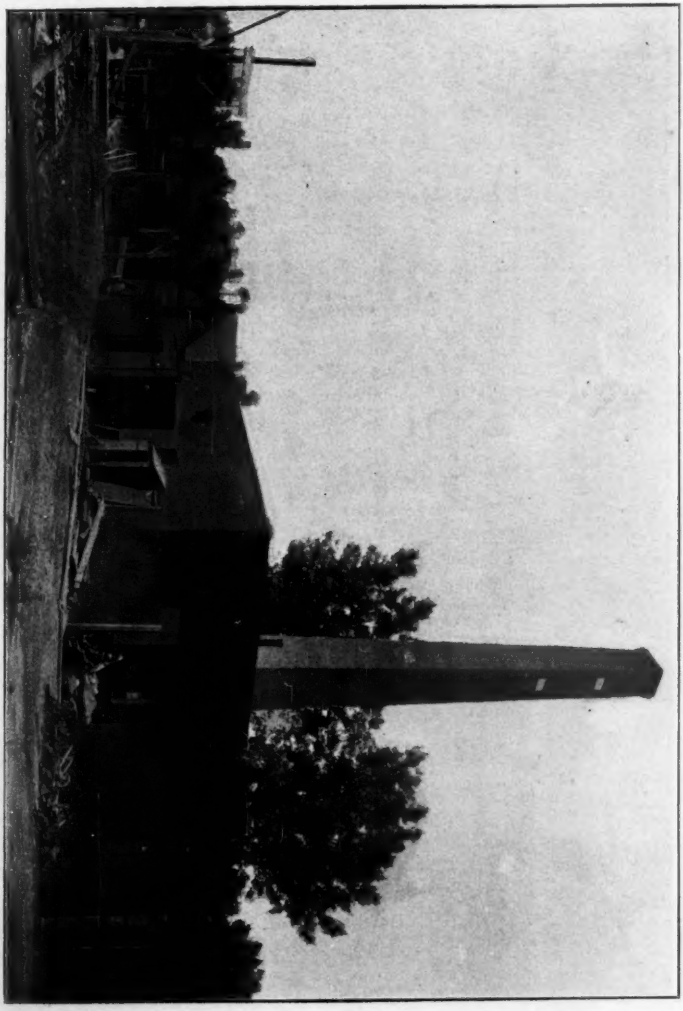
The pump and the engineer who was then in charge have since that time served the city faithfully and efficiently, celebrating the 27th anniversary of their association together in business in the midst of a conflagration which crumbled brick walls, collapsed cast iron pipes and left of the thickly piled lumber yard on three sides of the station, hardly ruins enough to indicate what it had been. A second three quarter million Worthington pump was the following year added to the plant at an expense of $8,000.

The Burlington water works comprise about thirty-five miles of street mains, about twenty-two miles of which are cast iron; two earth work low service reservoirs, with a combined capacity of about seven million gallons; one iron high service reservoir with a capacity of 163,000 gallons; a motor to furnish the supply for the high service; two Worthington pumps which formed a part of the original installation; two forty horse power horizontal tubular boilers and a twenty-four inch cast iron intake conduit nearly three miles in length, which was laid in 1894.

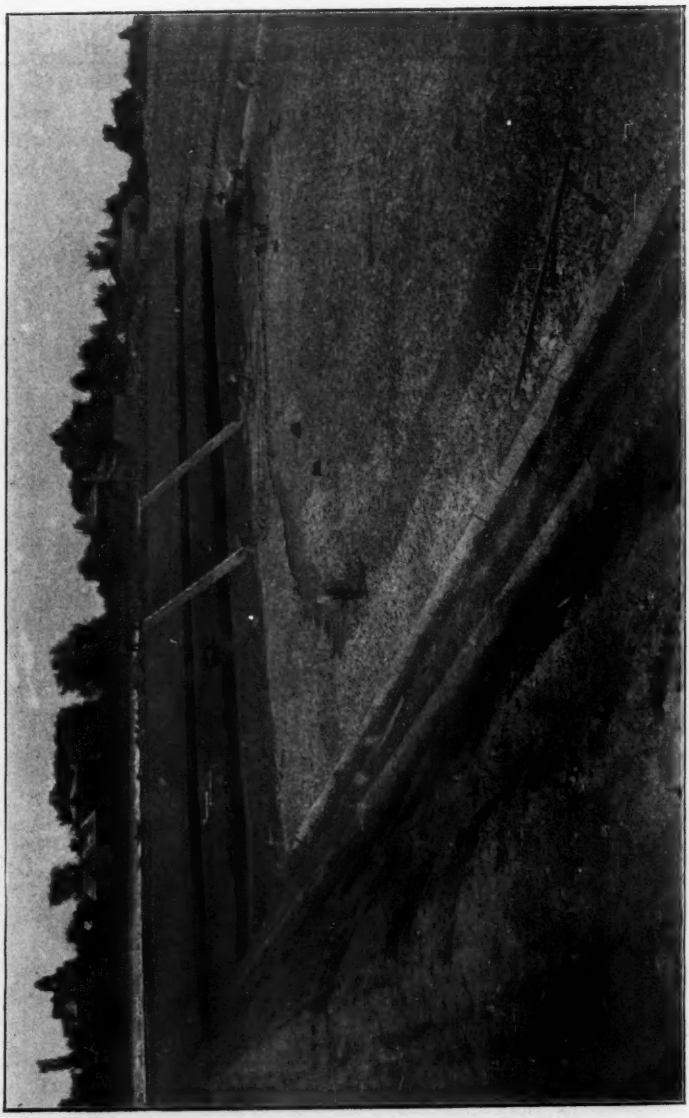
The new reservoir holding about four million gallons, was built in 1888, having a concrete bottom and slopes lined with brick laid in cement except for the upper third, against which the fluctuation of ice in winter is expected, which is lined with granite laid in gravel. The cost was about $23,000. Two years later about $11,000 were expended in remodeling the old reservoir, bringing it to the same general plan as the new one. Since then it has become possible to thoroughly clean the reservoirs, and that work has been done regularly each season, and there has been hardly any cause for complaint on account of fishy taste and odor.

The high service supply is furnished by a motor, designed and built by Mr. W. H. Lang of this city, which, for every 20 gallons passing through it either to or from the lower reservoir, forces about a gallon to the higher level. The motor is situated in the low service main in the low service reservoir yard and pumps directly into the distribution pipes of the high service, the surplus going to the high service tank, and in case the later overflows, the excess returns to the lower reservoirs.

The iron high service tank is thirty feet in diameter by thirty-two feet in height and rests on a stone foundation built up from solid



PUMPING STATION.



RESERVOIR DURING CONSTRUCTION.

ledge and is enclosed in a brick building with slated roof. The eight inch combined inlet and outlet pipe enters the tank about a foot above the bottom. A four inch overflow from the top conducts surplus back to the lower reservoirs. On the bottom a four inch blow-off is attached. On the side of the tank about two feet above the bottom and directly opposite the door of the brick building is an eliptical man-hole of sufficient size to admit men and tools for cleaning. Both the outside and inside of the tank have been covered at different times with several different paints and coatings, of which Alkatraz asphalt seems to give the best satisfaction.

Meters were used in Burlington even before the works were purchased by the city and since then the number has been constantly increasing. On the high service, a meter is required on every service where there is a sewer connection, owing to the insufficiency of the supply, the motor having for some time past been greatly over taxed. Meters are also required on all services larger than half inch used for other than fire purposes. Half inch meters are furnished by the city free of charge, the taker being at the expense of setting the meter in a manner approved by the department. Meter testing is conducted in the water works store room, which is conveniently fitted for that purpose and is abundantly supplied with water from a four inch service.

Our average daily consumption has now reached a point slightly in excess of the capacity of one pump, running all the time, and a new pumping plant will probably be soon installed both to secure greater capacity and the greater economy in operation of modern pumps over those of a quarter of a century ago.

From the construction of the works in 1867-8 to the fall of 1894, Burlington drew her water supply from a short distance from the face of the dock at the north of the bay and emptied her sewage at the south of the bay, of late years into a nicely, though entirely unwittingly, prepared settling basin. During all these years the sewage output has been on the increase but the various committees who have been delegated to investigate the matter have reported that though it was possible for the city's water supply to become contaminated from its proximity to the sewer outfall three-quarters of a mile distant, it was not at all probable. Later the above mentioned settling basin became a nuisance and the city forced to abandon it and proposing to empty her sewage directly into the bay

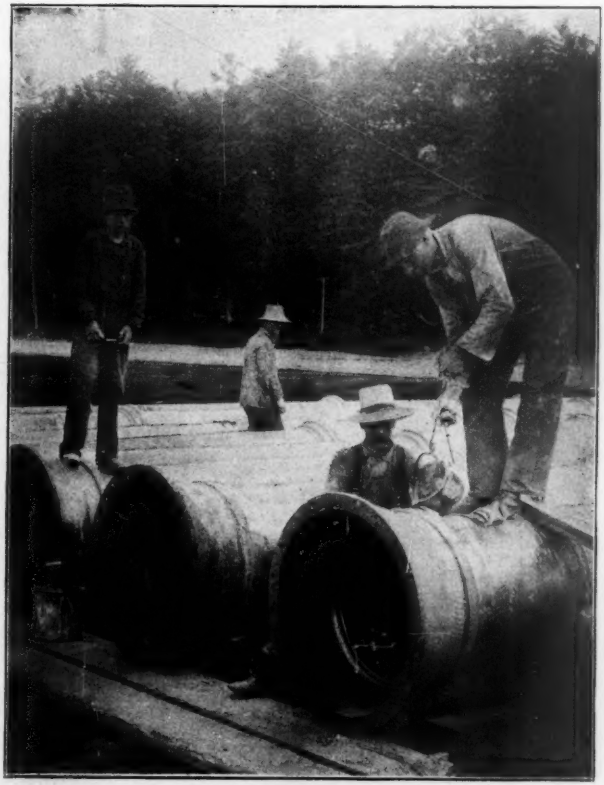
off the face of a dock, it became apparent that the condition of the intake all ready none too good, was likely to become worse.

Steps were immediately taken to remedy the evil and after a careful investigation of the possible sources of gravity supply and the different locations at which water could be taken from the lake, it was decided to locate the intake on what is known as Appletree Reef, just outside of the bay next north of that on which the city of Burlington is situated. Plans and specifications were prepared for the extension, the work was advertised and on October 7th, 1893, eight bids, ranging from $56,919 to $145,000 were opened at the water office. As the lowest bid was considered too high, bids were again asked for and just one month later, five were received, ranging from $47,900 to $59,500 and the contract was awarded to Mr. J. G. Falcon of Evanston, Illinois, the lowest bidder.

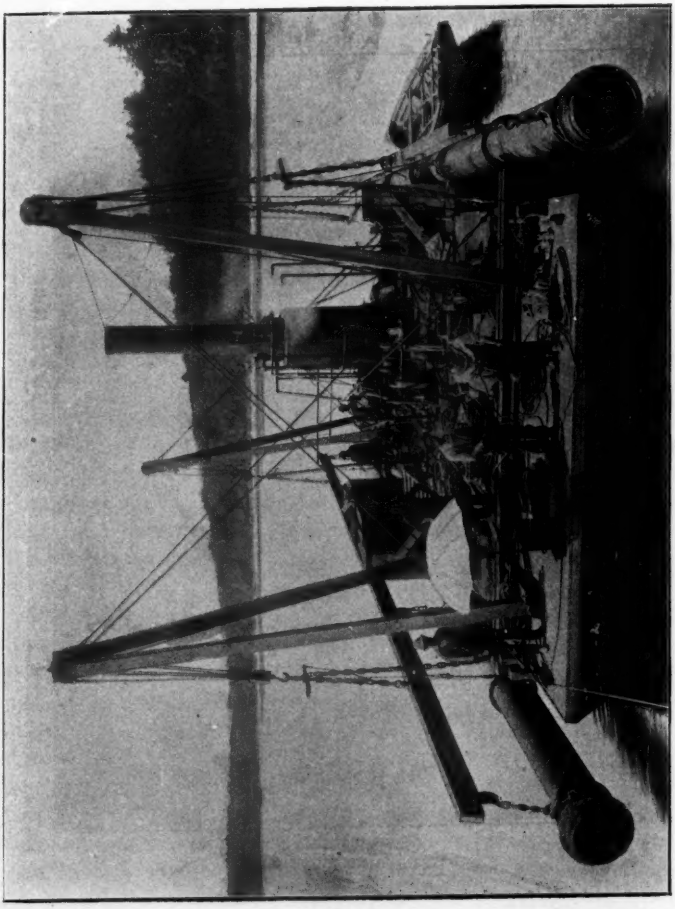
The intake conduit is of coated cast iron pipe, 24 inches in diameter, and was laid in sections of seventy-five feet each, connected under water by means of Falcon ball joints. This joint is made of a ball cast of such diameter, larger than the pipe on which it is to be used, as to admit the desired deflection to be obtained without obstructing the water way, and a flanged spherical ring of about three-eighths inch greater radius than the ball and of such width that the ball cannot pass through it. These two parts are leaded together and attached to one end and a flanged bell, planed so as to make a tight thimble for the ring which is attached to the other end of a section to be laid.

The flanged joint is made by a diver with the aid of a thin rubber packing, and after it has been for a short time in our lake water the oxidation which takes place on the planed surface of the ring and thimble makes it entirely water tight. In a case like that of our intake, where there is no current of constant and high velocity to keep open and increase the size of leaks induced by changes of temperature or settlement, it may safely be expected that all small holes will be closed by oxidation. The 75 foot lengths of regular bell and spigot pipe were leaded together on shore in the usual manner and were tested by hydraulic pressure, a special flange being bolted to each end for that purpose.

The scow used for laying the pipe was built and work commenced at the station in the winter and before the opening of navigation. The pump well was sunk, pipe laid through it from the face of the



FASTENING FLEXIBLE JOINT.



ON SCOW.

dock and a 24 inch gate placed on the conduit in the well. By closing this gate and placing a flange on the outer end of the last section laid, it became possible at any time to test the conduit in place in the same manner in which the sections had previously been tested on shore.

The outer or intake end of the conduit is located in about 30 feet of water on Appletree Reef, the end being turned up at an angle of ninety degrees and the size of the conduit increased at the bend to 30 inches. The highest point of the copper screen, which caps the upright, stands about fourteen feet below the surface at ordinary low water, and about five feet above the oak crib filled with stone which surrounds the upright. By closing a 24 inch gate, located just outside of the crib and the one before mentioned in the well at the pumping station, and forcing water under pressure into the conduit between the two gates, the tightness may at any time be easily tested. The tests which have been made, since the completion and acceptance of the work, have in each case proved satisfactory.

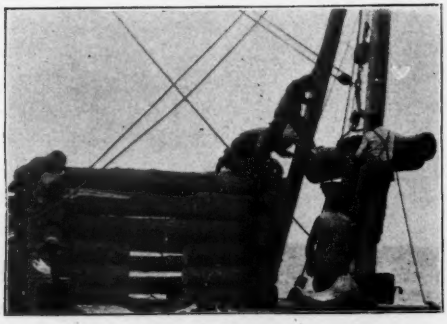
DISCUSSION.

MR. NOYES. If I understood him correctly, Mr. Crandall said that in the early part of the work, iron pipe was used, and that it did not give satisfactory results as compared with cement pipe. I would like to ask if there was any special reason to account for that, whether it was a poor iron, or whether it was owing to the peculiar quality of the water which acted upon the pipes?

MR. CRANDALL. I think that the trouble was occasioned by the quality of our water, which very readily attacks iron, and by the fact that there was no coating on the pipe. There was quite a lot of four inch pipe used by the Aqueduct Company, which was taken up at the time the new works were put in, and the pipes fell to pieces in taking them out of the ditch. Several years later, since my connection with the works, we amused ourselves when taking up some four inch pipe by stamping upon it and breaking it in. It was soft from end to end, and the iron thoroughly oxidized. We have a six inch main on Pearl street, uncoated pipe laid prior to 1865, which we expect will flood us every time we tap it.

MR. NOYES. I would like also to ask Mr. Crandall if he is now using coated iron pipe on the extension of his works, and if the water appears to attack the iron in the same way that it did the uncoated pipe?

1



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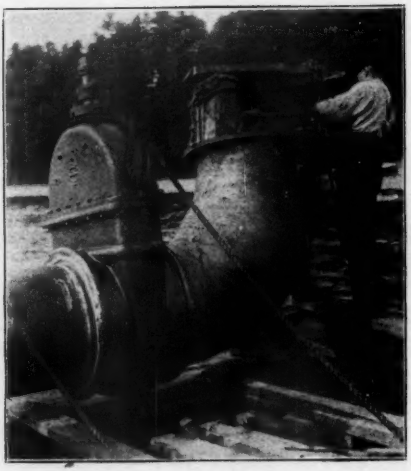
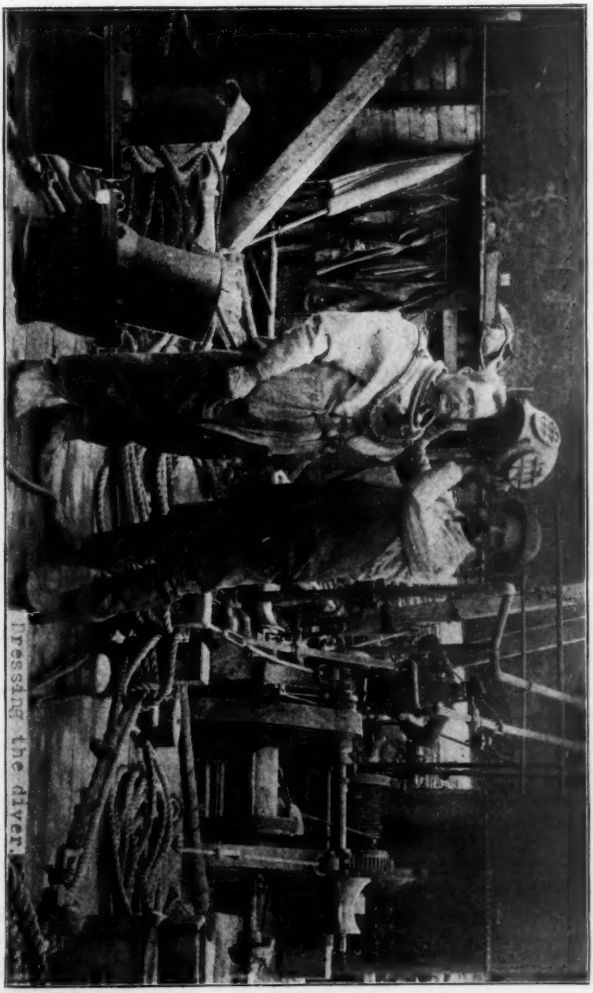


3

1—Screen. 2—Crib. 3—Gate and Bend.



PREPARING TO DESCEND.

MR. CRANDALL. We now use ordinary cast iron coated pipe. In 1888, we took out some pipe which had been down for 25 years, and it was found to have hardly a speck of rust on it. We are constantly taking out pieces of coated iron pipe which are in good condition.

A MEMBER. I would like to ask about the material used for coating the high service tank, particularly the inside.

MR. CRANDALL. We have used the government water-proof paint; the Dixon Graphite Company furnished us with a sample, and a local paint dealer has tried his hand at it; in fact the paints which have been used on that tank are too numerous to mention. About four years ago the Alkatraz Asphalt Company of Portland, Oregon, offered to give us a barrel if we would pay the freight on it, and the asphalt is now on the tank inside and out, covering about a quarter of the surface, and thus far it has proved satisfactory. It does not peel and the ice does not seem to affect it; it is just as good where the fluctuation occurs as it is at the bottom.

MR. WILLIAMS. I would like to enquire a little more about the test of the intake. Mr. Crandall stated that the tests were satisfactory; but I would like to know exactly what his tests were, and their results.

MR. CRANDALL. The pipe is laid on a bottom which is nearly level, but there are two summits in the distance, and on those summits were placed brass ferrules with two one-eighth inch holes bored in each ferrule. Before these holes were opened, the water was let on at a pressure of about 20 pounds, and we noted the amount of leakage and the same was done afterwards, showing the leakage occasioned by the holes. This was done each time that air vents were placed, and when the test was finally made, the pressure which they were subjected to was from 12 to 15 pounds, and the leakage, aside from that through the air vents, was about 100 gallons per hour in the entire length of about three miles.

MR. GILBERT. I would like to ask a question in regard to the action of water on iron. We have all noticed that some pipe will fill up with rust much quicker than other pipe, not only in the mains, but more particularly in services. I am speaking of plain iron pipe, not coated pipe. Now it seems to me that this difference must be due to the quality of the iron; and I would like to know what quality of iron is least acted upon.

A MEMBER. I find that all common iron pipe, standing in water, will rust at about the same rate, and as far as I can see, the quality of the iron makes no difference. I think the filling up of a common iron pipe depends largely upon the pressure; services where the pressure is low fill up quicker than where it is higher. I have also noticed that the rust upon common iron pipe is much more easily washed off than it is from a coated pipe.

MR. GILBERT. We had a case where two services were connected with a main within two feet of each other. They were both laid the same year, but probably not from the same lot of pipe. The water from one of those services was satisfactory all the time, but from the other it was hardly fit to use. The water from all the other services along the street was good. The service pipe was finally changed and there has been no further trouble.

MR. FISH. I have always found that rapid rusting of service pipes has been accompanied by leaks, so that the water is constantly flowing through the pipes, and I would suggest that leaks be looked for in all such cases.

MR. HAZEN. One of the most interesting features of this Burlington supply is the use of Lake Champlain, both as a source of water supply and as a receptacle for the sewage of the city. That is a case which does not occur very often in New England, but which is much more common in the West. On the shores of the Great Lakes there are a number of cities, many of them much larger than Burlington, that are doing this same thing, and the question comes up in all these cases, how much is it necessary to dilute the sewage in order to make it safe for drinking water; or, in other words, how far out must the water intake be placed in order to get a safe or healthy drinking water, or can the intake be so placed at any reasonable distance as to give a safe water?

There are cases, as for example those of Chicago, Cleveland, Toronto and other lake cities, where the water has been taken from points too near the sewer outlets, and there has been so much sewage in the water that the cities have suffered from very high death rates and from sickness which they ought not to have had, and would not have had with better water; but, on the other hand, we must admit that there is a distance from which water may be taken that is far enough away from the sewer outlets so that the sewage will have at least no very great effect upon the health of the city.

The Chicago sewage mixes with the water of the lake and pollutes it so that, as I believe, it is not suitable for drinking, even at the four mile intake; but following the case further, we find that the sewage mixes with the water of Lake Michigan and eventually goes down through the Mackinaw Straits into and through Lake Huron and finally into the Detroit river and into the drinking water of Detroit. But after it has passed through these two great lakes and has become so enormously diluted and exposed to the air and light for months, no one would claim there was any serious danger from the Chicago sewage to the Detroit water. The engineer of the Detroit water works is here, and I think if he were looking for possible pollutions of the Detroit supply, he would look for them at points much nearer than Chicago. But the intake of the Chicago water works and the intake of the Detroit water works are a long distance apart, and the interesting question is at what point between those two limits does the water become safe for drinking and suitable for public water supply.

It seems to me that there is not any sharp line, but that the further the intakes are carried out the less the danger becomes. When Chicago carried her main intake out from two to four miles and abandoned at the same time the use of the old shore inlet, some three years ago, the death rate from typhoid fever in the city in the next year was reduced by 60 per cent., or to 40 per cent. of what it had been before.* That was regarded as a great achievement, and it was. The water was better, but it was and still is far from what it should be. The city, even since the reduction, has an enormously high death rate when it is compared with other cities with good water supplies. The four miles was not far enough; and it will be necessary to go much farther than that in order to secure a good water. Of course the distance to which it is necessary to go, depends in different cases upon the amount of sewage which is put in, and a large city like Chicago, disposing of the sewage from over a million people, pollutes the water to a greater extent and for a greater distance than a smaller place would do.

The question is naturally raised as to how much disease a water must cause in order to make it worth while to incur a heavy expen-

*The Water Supply of Chicago, its Source and Sanitary Aspects, by Arthur R. Reynolds, M. E. Commissioner of Health of Chicago, and Allen Hazen, American Public Health Association, 1893. Page 146.

diture to prevent it. It seems to me we have got to put this question upon something the same basis that we do the cases of other works for saving human life. If it is a question of abolishing a grade crossing, a city will not incur an expenditure of millions of dollars to save one or two human lives, but if the expenditure is less, or if many lives can be saved, the improvement will be demanded. It is necessary to show that the value of the lives bears some relation to the expense which is to be incurred in making the change. And that is what I believe should be done in regard to works for improving the quality of water supplies. The method which has suggested itself to me is to take the deaths which can be attributed with some degree of certainty to the water, and the losses arising from the sickness which comes from the same source, and estimate their value upon something the same principles which are used in other cases where the damage to and loss of human life are involved, including also an allowance for indirect damages, such as depreciation of property, etc., which cannot be so accurately estimated, and balance the damages done by the water, calculated in this way, against the cost of the works which would be necessary to secure a water which would avoid them, or most of them, and then determine whether the saving is enough to justify the expenditure of the money necessary to make the changes.

And I think you will be surprised in many cases, to find how great the saving will be, and how much expenditure it will justify to avoid the sickness and death. Take for example Chicago. In 1891, 1997 deaths were reported from typhoid fever. Probably more than 15,000 other people were seriously sick from this disease but did not die from it. The fever was, in my opinion, mainly due to the use of the Chicago water. It may be said that some cases would have occured had the city had ever so good a water supply, but on the other hand there were hundreds or thousands of other cases which were contracted in Chicago by people who were there temporarily, or who were working there, and left the city after they had contracted the disease, and so a part of typhoid fever contracted in Chicago was charged to the account of the cities and towns to which these people went. Taking this into account, I do not think the figure given is an over-estimate of what was actually caused by the water. Most of the victims were people in the prime of life; there were few children and few old people. All classes of

society were effected to substantially the same extent, for we found that the wards along the lake front, where the finest residences in Chicago were located, had just as high death rates as those on the west side, and those along the Chicago river, which were in bad sanitary condition, and were commonly supposed to be the main strongholds of the disease.

Taking these facts into account, it seems that a value of not less than $5,000 should be put upon each of these lives, and that, for 2,000 lives lost, you see, aggregates $10,000,000 loss in one year alone, and that without taking into account the enormous number of cases of sickness which did not result fatally, or the diarrhœa and other minor injuries to health which were undoubtedly caused by the water, but which do not appear in the statistical reports of the Health Department. That $10,000,000 was the loss in one year, and was followed of course by other sums for other years, and the loss is of such a magnitude that it would fully justify very heavy expenditures to prevent it, such as would allow the positions of the intakes to be radically changed, or the treatment of the sewage, or the filtration of the water, as it has been found at Lawrence and in Europe it can be done, so as to render it safe for use. The case of Chicago is not exceptional, as precisely the same conditions prevail to a greater or less extent in many other cities. It seems to me we have got to look at this question in this general way, balancing the losses which result from the use of a poorer water, as nearly as we can calculate them, with the cost of improving the supply.

Professor Sedgwick is going to tell us tonight something about the conditions here in Burlington. I believe that they are comparatively good, and that Burlington, being a small city, and having extended the water intake out, as Mr. Crandall has told us, some three miles, the water obtained is comparatively good and the city has a low death rate from typhoid fever. But there are plenty of other cases where the conditions are different, and where the death rates are high, and it is a question which must be carefully examined wherever it is proposed to put sewage into the same body of water from which drinking water is taken.

ON THE SANITARY CONDITION PAST AND PRESENT OF THE WATER SUPPLY OF BURLINGTON, VERMONT.

BY

WILLIAM T. SEDGWICK,

Professor of Biology in the Massachusetts Institute of Technology, Boston, and Biologist to the State Board of Health of Massachusetts.

To the student of hygiene the sanitary history of the water supply of Burlington, Vermont, is peculiarly interesting and instructive. Burlington is the only city in New England which derives its water supply from the same lake into which it empties its sewage, although this arrangement for water supply and sewage disposal is common enough in other parts of the United States. It also affords a notable example of a community which has long used a suspected water without having suffered excessively from typhoid fever while yet exhibiting a condition of widespread and continued diarrhœal disturbance among its inhabitants; a condition which was apparently entirely due to consumption of impure water and has been apparently entirely corrected by simply increasing the distance between the sewer outfall and the water intake in the lake.

The location of Burlington is all that could be desired. Situated at the eastern extremity of Burlington Bay, on Lake Champlain, it occupies a very favorable sanitary position. The city is closely built over a small area only. For the most part it has an open suburban character and rests upon, or at the foot of, a hillside which rises rather abruptly from the lake and leads to an elevated and very extensive terrace or table-land stretching many miles to north and south, as well as eastward to the nearest hills—the higher ranges of the Green Mountains—some twelve miles away. Built thus upon the rather sharp declivity by which this broad terrace passes into the lake; with the Green Mountains on the east, and on the western horizon the sinuous line of the Adirondack peaks; while at its feet

the long lake reflects the shafts of sunlight and tempers the hot breaths of summer, the city has naturally a most fortunate situation. The climate, though cold in winter, is salubrious and the natural drainage excellent.*

Water in superabundance is at hand; and when, in 1866, the citizens determined to have an ample public water supply for fire and other purposes they naturally turned first of all for a source to Lake Champlain. Yet they did not finally decide to use the lake without due deliberation and careful inquiry.

"In 1866, when the matter of building our water works was under discussion, a gravity supply from Brown's River, in Jericho, was alluded to, and the matter was disposed of in the report in the following words: 'At no distance less than about eleven miles can we obtain a supply of water by gravitation from any place, and as this would involve an expense of about $500,000 such a mode of obtaining water at this time is out of the question.'"—(*Annual Report of the Water Commissioners of Burlington, Vt.*, for 1889, p. 95.) It was accordingly decided to abandon the idea of a gravity supply and to pump from the lake into the pipes, the surplus going to a reservoir at the top of the hill.

The water works were built in 1867, the intake being located on the lake front near the northern extremity of the docks. They appear to have given at first entire satisfaction. "At no time has the city water supply held so high a place in the public estimation."—(*Sixth Annual Report of the City of Burlington*, for 1870, p. 122.) As early as 1871, however, attention was drawn by the Health Officer (Dr. H. A. Crandall,) to the desirability of extending the intake further into the lake. "The prospect of increased sewerage, the increased shipping about the docks, the great amount of surface water flowing into the lake from our streets, besides other important reasons, influence me to recommend an extension of the pumping main at the

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*"Nature has done much to render Burlington both beautiful and healthful. It is unsurpassed among the places noted for the beauty of their location and their natural surroundings. Situated in the midst of mountain scenery, and bounded on the west by Lake Champlain, it possesses everything to contribute to good health. Opportunities for health-giving exercise abound, in walks, drives, mountain-climbing and yachting. * * * *

"The climate is not excelled for salubrity. While the vicinity of the lake modifies the extremes of temperature, both in winter and summer, the atmosphere is unusually bright and clear, and the proportion of sunshiny to cloudy days is about five to one in all seasons of the year."—(*Annual Report of the Health Officer—Dr. H. A. Crandall—for 1893.*)

pump house of the water works farther into the lake, say 300 feet or more, to deep and *pure* water."—(*Seventh Annual Report*, for 1871, p. 85.)

The occurrence of 5 deaths from dysentery and 3 from diarrhœa in 1870, and of 10 from dysentery in 1871, suggest that the "other important reasons" referred to by Dr. Crandall may have been the prevalence of diarrhœal disturbances. However this may be, the Health Officer for 1874 (Dr. A. P. Grinnell,) appears to refer to such a condition in his annual report for that year, and to have been moved to make an investigation. "It is generally believed that the water obtained from the lake is chemically pure and wholesome; but the prevalence of a certain class of disease whose origin could be traced to impure water or food has led me to make a more thorough investigation of the matter, and now I am able to place before the Board [the city council] the results of experiments, and the conclusions at which I have arrived, respecting the impurity of the water supplied to the people of this city."—(*Tenth Annual Report*, for 1874, p. 76.) The Health Officer then gives the results of chemical analysis of the water of the lake at the intake, one specimen having been collected from the surface and one from near the bottom, and continues: "The amount of organic matter found in either specimen is sufficient to warrant the statement that the water now supplied to the city contains impurities which are capable of generating diseases of a grave character. * * * * We can safely presume that the water consumed by the city is much of the time unfit for use. * * * * The necessity of supplying pure and wholesome water for purposes of drink and diet is apparent to everyone; but it is hardly possible to obtain such supplies from a point in the lake only *sixty feet* from the docks—the natural reservoirs for the excrementitious matter found in sewage." Dr. Grinnell also advised the extension of the intake pipe, "to or beyond the breakwater." (*loc. cit.*) This advice was repeated in the next Annual Report by the Health Officer for 1875 (Dr. C. P. Thayer.)

On the other hand, in the *Fourteenth Annual Report*, for 1878, p. 198, the Health Officer (Dr. H. H. Atwater) states: "In my observation of the diseases of this city and their causes during the period from the introduction of the public water supply to the present time, I have been unable to trace any distinct ill effects from the present source of supply. Typhoid fever, the disease which, of all others, we should

expect to result from sewage contamination of drinking water, is of infrequent occurrence in this community. There has been only one death from this disease during the last year, and this of a man over 70 years of age. Diarrhœa and dysentery occur here sporadically, and are not virulent, and prevail mostly during the summer months, so that they may be more reasonably attributable to the debilitating effects of heat, over-exertion and other causes, than to impure drinking water. * * * * Still, it seems to me that as the number of public sewers and the amount of sewage flowing directly into the lake yearly increases, it would be wise for the city to consider soon the propriety of obtaining the water at a greater distance from the shore."

In 1882, out of a total of 254, there were eight deaths from typhoid fever and eight from diarrhœa and dysentery, besides three from cholera morbus—a sum of diarrhœal disease which amounted to an epidemic.

In 1883 the Health Officer (Dr. John B. Wheeler) states: "First in the list of improvements, by which the public health would unquestionably be benefited, is the extension of the water main to some point outside the breakwater. * * * * It can hardly be doubted that much of the diarrhœal trouble so common in Burlington is due to the condition of the city's water supply. To extend the water main beyond the breakwater would be to take it beyond the reach of contamination and give our citizens a supply of pure water."—(*Nineteenth Annual Report*, for 1883, p. 88.)

Dr. Wheeler, as Health Officer, in the next annual report, says: "Some alarm was created, in the early summer, by the appearance of typhoid fever in the city. The alarm was owing not so much to the number of cases, which was not large, as to the existence of the disease, which is almost unknown in Burlington, except when an occasional case is imported. The number of fatal cases in 1884 was 10. * * * * The character of our water supply has been the subject of a good deal of discussion during the past year."—(*Twentieth Annual Report*, for 1884, pp. 55, 56.)

In 1885, the Mayor of Burlington, in his annual *Message*, said: "The subject of a supply of purer water for our city has been much discussed, and opinions are various among our citizens. * * * * Several analyses of water taken from different parts of the lake,—and from other waters than the lake,—have been made by compe-

tent chemists, and they indicate that we should not be materially benefited by changing the present source of supply. Whether analyses should be taken as conclusive evidence of fitness or unfitness of water for human use I am not prepared to say, but common sense would teach that, other conditions being equal, the greater the distance water is taken from a source of infection, the purer it will be." In the same report (*Twenty-first Annual Report*, for 1885) the Health Officer, Dr. J. H. Linsley, remarks: "The fact that no case of typhoid fever was reported to the Health Officer during the year refutes the possibility of the cause of the appearance of this disease in 1884, being in our water supply, as was at that time suggested."

During 1884 and 1885 numerous chemical analyses were made and in the Mayor's message, delivered on April 5, 1886, we find the following conclusion based upon them: "Some two years since the water committee were directed to examine into the subject of our water supply, and to report the result of their investigations to the board. They have just made their report, which contains the results of many analyses of water taken from various localities in the lake. The report imparts the gratifying assurance that the water at the point from which it is now pumped is as pure, if not purer, than at any other locality in the lake. There are some people who do not appreciate the value of the findings of the committee."—(*Twenty-second Annual Report*, for 1886, p. 13.) In the same *Report* (p. 74) the Health Officer (Dr. J. H. Linsley) remarks: "More or less discussion is constantly going on in regard to our present water supply, and many views are entertained as regards the comparative purity of the water used. I am unaware that the existence of any disease was ever traced to its impurity. But I think no one will deny that the surroundings of the suction-pipe, as at present situated, are not such as would tend to quiet the misgivings of anyone who is inclined to be skeptical in regard to the purity of the water at our present source of supply. I would respectfully recommend that when it is seen fit to extend the suction-pipe into the lake, such extension be made far enough to be beyond the *possible* contamination of the sewage from this city. Of course, the construction of the sewer in Battery street removes nearly all the sewage that formerly emptied into the lake at the foot of College street, to a point fully half a mile further south" Also, in the

same *Report* (p. 99), the superintendent of water works (Mr. F. H. Parker) states: "By a vote of the board of aldermen, May 17th, 1886, the city treasurer was authorized to borrow $24,000 * * * * for the purpose of * * * * and extending the suction-pipe to the pumps farther into the lake." * * * * "A city meeting was called, * * * * but the resolution authorizing the work was dismissed, and the improvements have not been carried out."

For 1888 we find in the report of the Health Officer (Dr. J. C. Rutherford) the following: "There was more sickness during the year just ended than for several years past. * * * * Different types of fever prevailed during the late summer and autumn, some of them taking a typhoidal form. The mortality from them, however, was very low. On December 24 I sent to the physicians of the city a circular letter requesting them to give me, to the best of their knowledge, the number of cases of fever they had attended during the past year. Nearly all replied, and although they said they had no record of their cases, the number they remembered was, in the aggregate, very large. They ascribed the cause of so much sickness to, First—the long-continued wet weather. Second—the sudden changes of temperature; and Third—the unwholesome condition of the aqueduct water. * * * *

"There have been reported to me twenty-six cases of typhoid fever. The source of only two could be traced from out of town; the rest, beyond any reasonable doubt, originated here. Many other cases were reported as typhoid, which, upon examination, I found to be of another type of fever. * * * *

"The water supply of the city has again become a prominent topic of conversation. Owing to the great amount of sickness during the summer and autumn, people have begun to question the purity of the aqueduct water."—(*Twenty-fourth Annual Report*, for 1888, pp. 74–77.) In the same document Mr. F. H. Crandall, who began his service as superintendent on April 25, 1888, (succeeding Mr. Parker, who became chairman of the newly-established water commission), in making his first report, says (p. 131): "The unusual amount of sickness in our city for some time past has again called public attention to the purity of our water supply. Various plans for its improvement have, for some time past, been under consideration, * * * * and investigations are now in progress as to the relative merits of different sources of supply."

The results of the "investigations" here referred to appeared in the next Report (*Twenty-fifth Annual Report of the City of Burlington, Vt.*, for 1889, pp. 95, 105, 113. See also *Twenty-third Annual Report of the Water Department, City of Burlington, Vt.*), and consisted mainly of a report of progress. The documents referred to are duplicates, and include statements from the commissioners and superintendent, and a lengthy and interesting summary of the situation from the chemical standpoint by Mr. Joseph L. Hills, chemist of the State Agricultural Experiment Station of Vermont. From Mr. Hills's report is taken the table of analyses given on the next page.

Mr. Hills himself added to this list twenty-three more chemical analyses, made at the Experiment Station between May and November, 1889, from the city service, various points in Lake Champlain, and several places from which it had been proposed to obtain a gravity supply.

From his several investigations Mr. Hills concluded that "The testimony of chemical analysis would appear to be, so far as one year's experience can indicate, that all the [proposed] sources of supply are of medium purity, except perhaps, Hinesburg Pond. * * * * The station chemists have not been able to detect evidences of sewage in samples from Mark's Bay or the pumping station (or indeed in a series of samples taken about one hundred yards away from the sewer mouth in the endeavor to trace the direction of sewage currents.) * * * * One of the most interesting points * * * * is that the water from the broad lake does not appear purer than that taken inshore. * * * * It does not appear settled that the extension of the suction-pipe will of necessity give our community a purer water supply."

Reviewing all the facts and data observed or collected up to this time, the superintendent (Mr. Crandall) wisely and truthfully remarked in his annual report for 1889, that they "afford a subject for careful thought and study, as well as a chance for interesting comparisons."

In 1890 the Health Officer (Dr. J. C. Rutherford) reported that "During the present winter there has been in the city a mild epidemic of diarrhœa, which some people supposed was caused by impure water. A meeting of the State Board of Health was called in this city, at which several of the prominent physicians gave their

CHEMICAL ANALYSES OF THE WATER SUPPLY, ETC., OF BURLINGTON, VERMONT, PREVIOUS TO MAY, 1889.

[COMPILED BY JOSEPH L. HILLS.] [Parts Per Million.]

Source of Sample.	Date.	Analysis By	Free Am.	Alb. Am.	Total Solids.	Fixed Solids.	Vol'tle Solids.	Chlorine.
Hydrant	1882	Mallet	0.035	0.14	70	20	50	0.7
Service Supply, Elmwood Avenue	Sept., 1884	Sabin	0.04	0.18	164	....	....	.....
Mouth of Suction Pipe, Pumping Station	"	Sabin	0.16	0.16	36	.....	.....	.....
" " " " "	"	Witthaus	0.052	0.13	72	.....	.....	2.1
" " " " "	March, 1885	Witthaus	0.034	0.10	89	.....	.....	1.1
" " " " "	"	W. R. Nichols	0.02	0.15	71	57	14	0.2
" " " " "	"	Seeley	.....	.....	60	41	19	.....
" " " " "	Jan. 8, 1889	Hills	0.03	0.18	88.5	54.5	34	1.7
Northwest corner of Breakwater, 10 feet deep	Sept., 1884	Sabin	0.06	0.114	119	.....	.....	.....
" " " " "	"	Witthaus	0.026	0.11	84	.....	.....	1.5
" " " " "	March, 1885	Witthaus	0.016	0.08	75	.....	.....	1.1
" " " " "	"	W. R. Nichols	trace	0.08	73	60	13	2.0
Foot of Bank Street	Jan. 8, 1889	Hills	0.02	0.19	86	49	37	1.4
Northwest corner of Breakwater, 26 feet deep	Sept., 1884	Witthaus	0.146	0.17	79	.....	.....	1.8
" " " " "	March, 1885	Witthaus	0.034	0.08	76	.....	.....	1.0
" " " " "	"	W. R. Nichols	trace	0.08	70	55	15	1.8
Marks' Bay, 58 feet deep	Sept., 1884	Sabin	0.048	0.10	107	.....	.....	.....
" " 62 " "	"	Witthaus	0.08	0.10	56	.....	.....	5.8
" "	March, 1885	Witthaus	0.034	0.05	66	.....	.....	0.9
" "	Jan. 8, 1889	Hills	0.03	0.16	80	45	35	2.9
Surface, midway Sewer mouth to South end Breakwater	Sept., 1884	Sabin	0.04	0 072	100	.....	.....	.....
" " " " " " "	"	Witthaus	0.08	0.13	116	.....	.....	9.7
Three thousand feet west of Pumping Station	March, 1885	Seeley	.....	.....	69	52	17	.....
Rock Point	"	Seeley	.....	.....	61	44	17	.....
Reservoir Water, 48 hours pumped	Sept., 1884	Sabin	0 093	0.168	129	.....	.....	.....
Reservoir Water, (*Old Reservoir*)	Dec. 29, 1888	Hills	0.03	0.16	80	45	35	2.9
Reservoir Water, (*New Reservoir*)	"	Hills	0 03	0.18	88.5	54.5	34	4.3
" " "	Feb. 12, 1889	Hills	0.04	0.14	....	.....	.....	2.4
Hinesburg Pond	March, 1885	W. R. Nichols	0.06	0.20	63	50	13	2.6
" "	"	Seeley	....	....	53	33	20	.....
" "	Feb. 13, 1889	Hills	0.04	0.15	93	43	50	3.7

testimony, and the majority of them were of the opinion that the sickness was caused more by the variable weather than by the water. Anyone who doubts the purity of our water would be convinced that it is pure if he will take the trouble to visit the pumping station and the reservoirs." (*Twenty-sixth Annual Report* for 1890, p. 73.)

In spite of this "mild epidemic of diarrhœa," no death from this cause is reported for either 1890 or 1891. Two deaths were reported in 1890 from dysentery, one each from typhoid and continued, and two from typho-malarial fever.

The total mortality, the typhoid fever mortality, and the percentage which the latter was of the former, for the twenty-six years 1870–1895, are shown in the following table:

TYPHOID FEVER* MORTALITY IN BURLINGTON, VT.

(1870–1895.)

Year.	Total Mortality.	Typhoid Fever Mortality.	Mortality Percentage from Typhoid Fever.
1870	169	2	1.18
1871	146	6	4.10
1872	157	2	1.27
1873	228	..	....
1874	152	..	....
1875	145	..	....
1876	148	2	1.35
1877	202	4	1.98
1878	183	1	0.54
1879	228	2	0.87
1880	219	3	1.37
1881	226	2	0.88
1882	254	8	3.15
1883	242	1	0.41
1884	238	10	4.20
1885	266	1	0.37
1886	262	4	1.53
1887	286	4	1.05
1888	375	9	2.40
1889	248	8	3.14
1890	300	4	1.33
1891	272	4	1.47
1892	336	6	1.77
1893	306	10	3.26
1894	311	2	0.64
1895	311	1	0.32

*Including "typhoid," "continued," "slow," "enteric," "bilious," and "typho-malarial" fevers.

MORTALITY FROM TYPHOID FEVER PER 10,000 INHABITANTS IN CENSUS YEARS.

Year.	Population.	Deaths from Typhoid Fever.	Deaths from Typhoid Fever per 10,000 Inhabitants.
1870	14,387	2	1.3
1880	11,364	3	2.6
1890	14,590	4	2.7

The general situation when, in 1892, I was invited to make an investigation of the sanitary condition of the water supply appears, from what has thus far been brought together, to have been somewhat as follows:

First. It was widely held by physicians, and understood by the people, that diarrhœa was common among users of the water, especially those who had not become habituated to it, visitors to Burlington, if they drank the water, frequently suffering from some diarrhœal disturbance.

Second. The location of the intake of the water works was less than a mile from the outfall of the main sewer, and only a few rods from the docks.

Third. Typhoid fever, the ordinary measure of the sanitary condition of a water supply, was not then, and had seldom been, excessively prevalent in Burlington.

Fourth. Chemical analyses had indicated that the water supply of Burlington was at least the equal in purity of many well-known and excellent water supplies.

Fifth. Chemical analyses had failed to show any marked superiority in the water of the broad lake (the middle of Lake Champlain) to that at the intake, on the shore of Burlington Bay.

Sixth. Investigations had proved that it would be difficult, uncertain and costly, to procure a gravity supply from the mountains, because of their remoteness and for other reasons.

It is only fair to add that at the time of my own investigations and of making my report I was less familiar with some of these facts than I am now.

Previous to 1892 the sewer outfall had frequently attracted the attention of physicians and other citizens. When the water in the lake was low the sewage from the main sewer was not discharged

into the lake beneath the surface or even on the lake front, but ran in an open stream over flats laid bare by the receding waters of the lake and emptied into a small bay or basin connecting with the lake. The stench which at times arose from this torpid stream, from the flats and the bay, were highly obnoxious and objectionable, so that a demand had come, especially from the Board of Health and its efficient Health Officer, Dr. H. A. Crandall, for an improved outfall. Mr. F. P. Stearns, C. E., Engineer-in-Chief of the State Board of Health of Massachusetts was finally consulted, and advised an extension of the outfall to the main lake front with disposal there directly into the lake, and at a depth sufficient to be always below the surface.

I had already been making (in Boston) occasional bacterial analyses of the city water, the water of the lake, etc., for the water commissioners of Burlington, when, on June 20th, 1892, I was invited by them to visit the city and make a thorough investigation of the sanitary condition of its public water supply, present and prospective. I did as I was desired and subsequently presented a Report, of which the following is the principal portion:—

BOSTON, JUNE 30, 1892.

"*To the Board of Water Commissioners, Burlington, Vt.*

"GENTLEMEN:—I have the honor to submit to you a report upon my investigations, made at your request, concerning the sanitary condition of the Burlington water supply and the probable sanitary effect of certain proposed changes therein.

"I am informed that many of the physicians regard the water supply with suspicion, and I find that the successive Health Officers in their official reports have frequently referred to the water as more or less objectionable. I therefore undertook, first, to discover the actual effects of the water supply upon the health of the city.

"In order to do this in the case of a water supply suspected of sewage contamination it is customary to take as a measure the prevalence of diarrhœal diseases, and especially typhoid fever. I have therefore carefully studied the vital statistics of Burlington for the last twelve (12) years, comparing the mortality from typhoid fever with the total mortality and also with the number of inhabitants.

"The results show conclusively that the mortality from typhoid fever (and the same is true for diarrhœa and dysentery) has not been large in Burlington during the last twelve years. The average annual mortality from typhoid fever, from 1870 to 1891 in Burlington was 3.57 per 10,000 inhabitants."

I then went on to show that Burlington compared favorably in this respect with many cities having water supplies of undoubted purity, and stated that in respect to mortality from typhoid fever it had a better record than "many cities having water supplies of good reputation. This weighty fact alone justifies the conclusion that there is no positive evidence in the sanitary statistics of the city that the water supply is injurious to the public health. I may add by way of confirmation that during the last three years I have made repeatedly bacteriological analysis of the Burlington supply, and that I have found no satisfactory evidence of the presence of sewage in the drinking water.

"It is interesting and instructive to compare the history of typhoid fever in Burlington during the last six (6) years with that during the earlier half of the period under consideration, for in this way we may learn whether this disease is or is not increasing. If we do this we obtain the following results:—

TYPHOID FEVER* IN BURLINGTON, VT.

Six-year Periods.	Average Annual Death Rate from Typhoid Fever per 10,000 Inhabitants.	Average Annual Mortality Percentage from Typhoid Fever.
1880-1885	3.39	1.73
1886-1891	3.75	1.83

"These figures are certainly reassuring, and prove conclusively that there is no immediate reason for excessive anxiety or alarm for the sanitary condition of the water supply.

"It is, however, the opinion of many Burlington physicians, based upon their experience that the water supply is responsible for the occurrence from time to time of diarrhœal disturbances which, while

*Including "enteric," "slow," "continued," and "typho-malarial" fevers.

they very rarely result in death, serve to annoy and alarm the citizens. In the present state of our knowledge it is at present impossible to prove or to disprove this theory. The fact appears to be that such disturbances are common, and it is well known that the main sewer of the city empties into Lake Champlain, the source of the water supply, less than a mile from the intake. Whether there is anything more than coincidence in these facts it is impossible to say. In the present state of sanitary science, however, there can be no doubt whatever that the location of the intake of the water works, as near as it now is to the main sewer of the city, is highly objectionable if not positively dangerous. I can only regard it as a constant menace to the sanitary welfare of the city. It must be admitted as entirely possible that unpurified sewage driven by winds or carried by currents may be in the future, if it has not been in the past, conveyed more or less directly from the sewer outfall to the water intake.

"I have, therefore, at your request, considered the probable sanitary advantages of a removal of the intake of the water works to a point in the "broad lake" some three miles from its present position, and also those of a complete change from the lake to a mountain supply.

"In regard to the former—the broad-lake supply—I am of the opinion that it would be of very great advantage from a sanitary standpoint, inasmuch as it would so far remove the intake from the sewer outfall as to make it unlikely that raw sewage would ever pass from the latter to the former; while at the same time it would give more time for the purification *en route* of any sewage which might accidently so pass. Unless the city should become very much larger than it now is, the passage of sewage from the sewer outfall to an intake located, for example, on Apple-tree Reef, through the present sewer basin and the quiet waters of the bay, can only be regarded as a remote possibility.

"I may remark in passing that, in my judgment, one reason for the comparative immunity from epidemics of typhoid fever hitherto enjoyed by this city is that the sewage is held in a small bay for a longer or shorter time, according to circumstances, where it can to some extent become freed from the germs of disease.

"If Burlington could draw its water supply by gravity from mountain streams or storage reservoirs and secure abundant water

from an unpolluted watershed the danger of infection of the water supply would be done away. So far as I can judge, however, there are no streams of sufficient size and purity directly available. Storage would be an unavoidable necessity. But storage, while of great sanitary advantage so far as the germs of specific diseases are concerned, is apt to lead to disagreeable consequences in other directions. The water drawn from storage reservoirs is often more or less colored by peat, stumps, leaves, etc., and it not infrequently suffers fermentation with the development of organisms, acquiring thereby disagreeable and sometimes nauseous tastes and odors. If these compel the citizens to abandon its use and lead them to resort to polluted wells or other objectionable sources of supply, the sanitary consequences may be unfortunate. It will be seen, therefore, that while a mountain supply is in many respects highly desirable it is nevertheless true that its adoption in this case would be attended with the possibility of some undesirable consequences. It must be remembered that every new water supply depending upon the storage of surface water is an experiment. It cannot be undertaken without some risk of undesirable results.

"In fine, I am of the opinion that there is no positive evidence of any injurious characteristics in the present supply. But I believe, nevertheless, that in view of the common occurrence of diarrhœal disturbances reported by physicians, and on account of the menace to the public health involved in the present arrangement, some other source of supply should be found. I think that it would be of very great sanitary advantage to remove the intake as far as possible out into the broad lake. A mountain supply in storage reservoirs would afford complete relief from sewage contamination, but might involve serious troubles with microscopical organisms, tastes and odors.

"Respectfully submitted,

WILLIAM T. SEDGWICK."

This report was generally accepted as establishing the fact, that while there was no occasion for immediate alarm or excessive anxiety, it was imperative that steps should be taken, as soon as practicable, to improve the situation. The epidemics of 1882, 1884 and 1889 were not forgotten, and the figures submitted by me showed a perceptible, though slight, increase of typhoid fever and diarrhœal disturbance during the more recent six-year period. Accordingly,

after still further deliberation, it was decided to extend the intake-pipe some three miles from the sewer outfall into the lake to a point known as Apple-tree Reef, which had been found by repeated bacterial analyses to be a favorable one for the purpose. This extension, as has been fully described in the preceding paper by Mr. Crandall, was made in the summer of 1894. Its completion was undoubtedly hastened by the improved sewerage plan recommended by Mr. Stearns in 1892, and about to be carried out by the Sewer Commissioners, by virtue of which the main sewer outfall would be pushed outward to the lake front, the sewage discharged at all seasons beneath the surface of the lake. As soon as this improvement became assured, Mr. Crandall and the Water Commissioners, as well as the Board of Health, redoubled their activity in urging that the intake of the water supply should be removed further out into the lake, and all the more because the little bay in which at certain seasons the sewage fermented and doubtless worked itself to some extent free from disease germs, was now to be obliterated, so that fresh sewage might at times readily find access to the currents, if any, along the lake front, and at a point less than a mile from the intake of the water works.

I have lately had made by an assistant, Mr. S. C. Prescott, in the laboratory of the Vermont Agricultural Experiment Station—kindly placed at our disposal by Professor Jones, to whom our hearty thanks are due—a series of careful bacterial analyses of water taken from various points on the high service and the low; at the pumping station; from the pump well; and from the lake just outside—a point which corresponds to the old intake; from the lake front near the sewer outfall; and from the new intake on Apple-tree Reef. These show conclusively, both by comparison with analyses made before the extension of the intake and by comparison one with another, that the removal of the intake to a distant point in the lake has caused a marked bacterial improvement in the purity of the city water.

[These facts were then demonstrated to the audience by means of the stereopticon: actual plate "cultures" of equal amounts of water from different parts of the service, from the lake, the sewer outlet, the intake, pump well, etc., grown upon gelatin or agar and fixed by formaldehyde, being placed in the lantern and shown upon the screen. In this way a unique and striking demonstration was

afforded of—for example—the progressive and remarkable disappearance of bacteria from the sewer outlet, where they were abundant, to the old intake, where they were relatively few yet far more numerous than at the new intake or at any point in the service pipes.]

Chemical analyses, as far as they go, confirm the bacterial results, as may be seen from the following:—

Burlington, Vermont, September 4, 1895.

SANITARY WATER ANALYSIS.

(Parts in 100,000.)

	Residue on Evaporation.			Nitrogen.						Oxygen Consumed.	Chlorine.	Hardness.	Iron.	Microscopical Organisms in 100 Cubic Centimeters.		
				Albuminoid Ammonia.												
	Total.	Loss on Ignition.	Fixed.	In Solution.	In Susp'nsion.	Total.	Free Ammonia.	As Nitrites.	As Nitrates.					Diatoms.	Algae.	Blue-Green Algae.
Lake (old intake)	6.60	1.25	5.35	.0110	.0028	.0138	.0010	.0000	.0010	.2730	.14	4.2	.0060	3,550	1,400	200
Tap (city service)	6.20	1.05	5.15	.0072	.0048	.0120	.0000	.0000	.0100	.2496	.10	4.2	.0060	1,050	6,200	150

But there is yet another kind of evidence which witnesses still more eloquently to the improvement of the water supply. This is the testimony of the physicians of Burlington. As far as I have been able to communicate with them—and I have interviewed a number of the most prominent and representative—there is a surprising and remarkable unanimity of opinion among the local physicians to the effect that the peculiar diarrhœal disturbances which had so long prevailed in Burlington have, since the extension of the intake pipe, wholly ceased; and the physicians are enthusiastic in their recognition of the salutary change, which they attribute entirely to the improved water supply.

In view of all the evidence at hand—statistical, bacteriological, chemical and medical—I think we may safely conclude that the sanitary condition of the water supply of Burlington is now most excellent. If, however, in the future Burlington grows extensively and becomes a much larger city it will probably become necessary here, as in most large cities, to face once more the question of a pure

water supply. Special pains must also be taken to see to it that the intake pipe is kept intact and free from leakage. The unfortunate experiences of Toronto and of Buffalo with broken intake pipes afford ample warnings in this direction.

This is the first case within my own experience, now somewhat extensive, in which epidemic diarrhœa in a mild form has prevailed in a community for many years, having its ætiology in the consumption of impure water as has been proved by its apparent total disappearance on a change in the source of supply. The importance of the case in the history of water-borne diseases is manifest. It was complicated by the fact that typhoid fever, which is usually taken as a measure of the sanitary condition of a community, was here ordinarily by no means excessive, and that its occasional prevalence might easily have been due to some other cause than polluted water. The fact seems to be, however, that it was in truth really due to impure water, inasmuch as since the extension of the intake pipe in 1894 typhoid fever has practically disappeared. (See table, p. 175.)

It would seem fair to conclude, from the moderate occurrence of typhoid fever, while diarrhœa abounded, that germs of the latter disease, more hardy than those of the former, were frequently able to survive a journey from the sewer outfall to the water intake while those of typhoid fever, if present, usually perished. In future sanitarians will not be able by the test of typhoid fever alone to show that a water supply is above suspicion. A mild form of diarrhœa caused by polluted water may apparently prevail even in the absence of any constant or considerable excess of typhoid fever.

AN ELECTRICAL PUMPING PLANT.

BY

CHARLES A. HAGUE, C. E., NEW YORK.

[Read Dec. 11th, 1895.]

It is no doubt safe to say that all of us here have first been brought into contact with the pumping question during the age of steam; that age in fact still being in full force and evidence. But during the past comparatively few years, the use of steam in important cases, as in street railway plants, has been relegated to the background, so to speak, and the power required at the exact point of employment has been first converted into the electrical mode of energy. That is to say, in important and prominent directions, the steam power has been concentrated in large plants, where it could be best, most economically, and most conveniently generated; the power given out by the steam engines, converted into energy represented by an electric current, and then distributed to wherever required for useful work.

We have all become accustomed to the terms of horse-power, foot pounds, and pounds pressure to the square inch. The pressure of the steam being susceptible of being actually weighed by a scale, and the result expressed in ordinary terms of force. Then the actual, tangible motion of the steam engine piston, multiplied by the steam force shown by the steam engine indicator, brings to us the measure of the work done. This effect at the steam end of the machine compared with the result shown by a dynamometer, or by a pump delivering water against pressure, at the other, demonstrates the efficiency of the machine as a developer and user of power.

It is of course to be presumed upon the face of the evidence, and will be taken as a fact, that in these huge modern electricity generating plants, in which the power instead of being used directly in the form generated from heat, is transformed into the subtle form known

as the electrical current, that the immense investments of capital are justified by economy and profit. And, in considering this, it becomes apparent that the gain in centralizing power into large plants is not all the benefit derived, but that incidental advantages accrue; therefore the suggestion is born, that possibly in pumping water by the employment of the electric current, the effective economy of the modern steam pumping engine can be so nearly approached, if not surpassed, that in many cases the incidental advantages in using electricity will be sufficient to turn the scale in favor of the electrically driven machine.

The first effect upon the human mind in trying to grasp the points of an alleged improvement, is towards a comparison of the new idea with something already well known; and in considering the pumping of water by electricity, we instinctively grope about in the endeavor to ascertain the exact bearings of the new idea in terms sufficiently near to well known effects, to enable us to make an intelligent comparison. So, as the development of the electrical mode of power began, it was seen at once that the older methods of determining and measuring, must give way to new ones compatible with the elements involved. But the absolute necessity of retaining at least for a time, some vestiges of the older methods, has resulted in an interchangeability of terms which permits the results of the newer school of power, to be compared and reckoned alongside of the older.

Now, coming directly to the point in question, what is the comparison in economy between pumping by means of machinery driven by steam power and that driven by electrical power? Also, what incidental benefits can be gained by using electrical power at the pumps, although at the sacrifice of a certain per centage of the actual steam economy of the engine which might be employed in generating the initial energy?

Answering the first part of the question, or rather the first of the above questions, we must bring the comparison upon common ground, from the standpoint of power developed in each case, and, considering the economy of its development. With the modern steam pumping engine it is probably a fair average to take the efficiency as a machine at 87 per cent.; that is, we can assume that 87 per cent. of the indicated power of the steam end is realized in the work done in the water end. This is with a good average engine, and one of com-

paritively low piston speed, developing a horse-power in every day work with say 14 pounds of steam per horse-power and per hour, or say 16 pounds of steam per pump-horse-power per hour.

In considering the electrically driven pump, the electric current is to be generated in a dynamo driven by a high class stationary engine, and we find that in the transmission of the power it goes from the steam engine into the dynamo; thence in the form of an electric current of a certain potential and quantity by means of a wire into an electrical motor, and there expended in operating the pump. The power of the engine is of course to be indicated in the usual way, but as it leaves the dynamo it is to be measured by "volts," representing our ideas of pressure, and by "amperes," representing the quantity or volume of current, precisely as pounds pressure, and weight of steam consumed, is comprehended in the use of steam. The product of the volts and amperes giving the "watts" will bring us directly to horse-power by dividing by 746. The watts corresponding to our ideas of foot pounds to a certain extent.

Disregarding for the moment the friction of the steam engine, the efficiency of a dynamo may be determined by means of a dynamometer connecting the dynamo to the engine shaft; and a volt meter, and an ampere meter, attached to the conducting wires just beyond the dynamo. The efficiency being expressed in the per centage which the watts reduced to horse-power, bears to the horse-power shown by the dynamometer as being delivered to the dynamo by the steam engine. The reverse of this operation at the motor will indicate the efficiency of that machine; and these several items or factors combined with the indicated horse-power of the engine, and also with the pump horse-power, will give us the following results in comparing efficiencies.

To begin with let us restate the standard by which the comparison is to be made, viz: A steam pumping engine with a mechanical efficiency of 87 per cent., developing a pump horse-power with 16 pounds of steam per hour. The rate of steam consumption in terms of pump horse-power representing the price paid for the mechanical work obtained. The question of boiler efficiency being entirely thrown out of the calculation, as considered upon an equal footing for both sides of the case, although the facilities for handling and stoking fuel in a large electrical generating plant, from which power

could be bought, would give a decided advantage to the electrical view.

The high class steam engine at a comparitively high rate of rotation and at an actually high rate of piston speed, is put down at 91 per cent. mechanical efficiency, and at a rate of steam consumption of eleven pounds of steam per horse-power per hour. It is pretty generally conceded by good authorities that a first-class dynamo properly adapted to its work will give an electro-mechanical efficiency of 95 per cent.; and that an adequate electric motor will do equally as well. The loss of effect in transmitting the electrical form of energy from the dynamo to the motor will depend largely upon the length, size, and condition of the wires; but assuming that the very best of conducting conditions exist, this loss can probably be reckoned at 5 per cent. for an average case when the generating of the power is not in the same building as the pumping machinery. But if we should happen to be operating a specially designed "thermo-electric" pumping engine, so to speak, which the author has in view for the future water works requirements, the loss of conduction could be brought as low as 2 per cent., perhaps still lower. The efficiency of the pumping portion of the machine, reckoning from the point at which the power is delivered by the motor, to the net pump horse-power, is taken at 89 per cent.

It will be seen then that in pumping water under a pressure kept practically uniform, and with a full load, the ideal elements of economy for the multiple-expansion automatic steam engine, and for the generation, the transmission, and use of the electrical mode of energy, are at hand to a very great extent, allowing an extremely close proportioning of steam and electrical apparatus to the object in view. In the modern steam pumping engine there is a constant attempt to compromise to the best advantage between the slowly moving water and the demands of the rapidly moving steam; there being no economy in moving water rapidly, but a good deal in operating the steam part of the machine as quickly as possible, therefore this comparatively new mode of motion, offers some decided advantages in the shape of a mediator between the two well known elements of the pumping problem so far naturally opposed to each other in their association in the same machine. The conclusion which is at least in sight then seems to be to operate the water end of the machine at its best and most economical rate of speed; also give the

steam end the conditions best suited to its thermo-dynamics; and with the electrical element fill in the gap, and so provide a perfectly elastic communication between the two.

To sum up the factors of gain and loss, upon the electrical side of the account, and bring them all into one expression of "rate of steam consumption," in terms of pump horse-power, as representing the price paid for the mechanical work obtained, please note the following:

Efficiency of high class stationery engine..... .....91 per cent.
Steam consumption, per indicated horse-power per hour.....11 pounds
Steam consumption per hour per net horse-power .....12.07 pounds
Efficiency of the dynamo in delivering to the conducting wires, in the form of electrical energy, the net power given to it by the engine..... ....95 per cent.
Net efficiency of the dynamo as above, in terms of steam per horse power per hour..... .....12.70 pounds
Efficiency of conducting wires in a short circuit, delivering electrical energy to the motor portion of the electrical pumping engine..... .....98 per cent.
Net efficiency of wires as above, in terms of steam per horse-power per hour..... .....12.95 pounds
Efficiency of motor mechanism in transforming electrical energy into mechanical power in pumping engine..... .....95 per cent.
Net efficiency of mechanical power delivered in terms of steam per horse power per hour .... 13.63 pounds
Possible mechanical efficiency of the pumping part of the machinery..... ....89 per cent.
Net efficiency of the electrical pumping engine under full speed and full load, in terms of steam per horse-power per hour... 15.30 pounds

The above result represents about 71 per cent. efficiency of the machine as far as steam consumption compared with useful work is concerned, or in other words, the net pump horse-power is 71 per cent. of the indicated steam horse-power; and from the general idea that 65 per cent. is considered safe in an off-hand statement, it certainly looks as though in the absence of any exact examination of such a plant in operation upon a large scale, that the efficiency herein given is not too high.

If such a showing as that given above could be made with a plant exclusively used for pumping it might be possible to considerably reduce the cost of pumping city water below present current figures,

by utilizing a portion of the steam and electrical machinery employed by some cities for lighting purposes; or, power might be bought from the electric railway and lighting companies; or, still further, where light, power, and water are combined under the control of one corporation, an arrangement of electrical pumping machinery might be made that would be well calculated to effect the general economy of operation for the better. These considerations would come under the second question, concerning the incidental benefits to be gained by the use of the electrical power.

In cities having hilly districts, and where it is necessary to supply residence districts by high service pumping plants, it seems to the author that the electric pump is destined to be of great value. Even in New England, where anthracite coal is largely used, the presence of a tall chimney, however useful it may be, does not add particularly to the appearance of the landscape, to say nothing of the dust and fine ashes liable to be spread broadcast about the neighborhood. But where bituminous coal is used, and soot and smoke are added to the other items of discomfort and uncleanliness, the strong points of the new school of power begin to appear.

For high service pumping the steam power and the dynamo could be operated at the main pumping station, near the water supply, needing in such a case only one boiler plant, and having only one chimney, the electric current being conducted to the upper pumping station. Of course people must have water, and that, no doubt, is the first consideration, smoke or no smoke, but at the same time the very presence and use of water encourages ideas of cleanliness and convenience, until after a while we are educated up to a point of refinement that begins to assert itself against anything that will soil and encumber; even if such annoyances are only a slight penalty we are called upon to pay for the benefits secured. Still if we can keep the benefits and avoid the dirt, and electricity is to be the means of accomplishing such a desirable end, then this item may be set down among the incidentals.

In the high service department the supply goes mostly to residences, and the rate of water per capita in such districts is very much below that of manufacturing and commercial areas; therefore the per centage of the total supply from a main pumping station, represented by the amount necessary for the high service districts, is naturally quite small in most cases. But supposing that it was as

much as 25 per cent., and supposing that in pumping the total supply under a pressure adequate for the delivery of this 25 per cent. at its destination, the power is increased say 50 per cent., it must be obvious that a division of the labor between a main pumping station and a high service station would result in a direct saving of a very considerable difference in coal consumed. Of course there is nothing new in high service pumping stations, as you are aware, but the way the thing is done now is after a high service station has been decided upon to build a complete steam plant, including boilers, chimney, storage for coal, and all of the details necessary for continuous operation and with some idea of future growth.

Here we have then, for supplying our city with water, not only the necessary pumping capacity but also two separate steam generating plants, with two sets of boiler appliances, and two sets of incidental expenses. And not only incidental expenses, but a direct comparison between steam and electricity of real operating costs, touching one or two important items, shows that before long the steam machinery, under some conditions at least, will have all it can do to hold its own. There is not sufficient data as yet to form a definite conclusion as to the relative costs of direct steam and electrical power, but roughly and as far as has been seen, if steam power is generated in large quantities, say 500 horse-power and upwards, the cost line of coal is about $3 per ton, where it begins to pay to buy electricity for power from such plants, for purposes of pumping water.

There is scarcely room to doubt the economy of employing the electrical mode of power for high service pumping, either to buy it from a power or light company, or to generate it at the initial pumping station, and when we consider the fact that the horse-power of pumping engines is comparatively low, and that the fixed charges are abnormaly high, the possibility of cheap electrical pumping in the initial station begins to attract attention. All of the tendencies in the pumping station are in the direction of high cost, and in the large electric station towards low cost. Practically the cost of the same number of attendants is divided by a very small amount of power in one case, and by a very large amount in the other, also the steam cylinder conditions are much in favor of the electric generating plant.

The lowest record known to the writer, for cost of steam power in a large plant of 1,200 horse-power, is $55 for 24 hours operation.

per horse-power per annum. Coal at $1.35 per ton of 2,000 pounds. The cost of the coal was about one-half of the total, so if the coal had been $3 per ton the power would have cost $88; and if the results had been upon the basis of the average pumping engine, the cost of a horse-power per annum would likely have been as high as $140, and at such a rate as that electricity would pay. In the above calculation there are included coal, operating expenses, interest, taxes, insurance, and repairs. There are in this country two large high class pumping engines from two different makers, representing the best probably, all things considered, that can be done at the present state of the art. The most economical one develops a horse-power per annum at a cost of $105, and the least economical one of the two at $87, the most economical being the most expensive to operate on account of the greater fixed charges against a much higher cost of plant. Dropping down the scale, there is little doubt of there being many pumping engines in public service less economical, all things considered, than a good electrical outfit would be.

Now we desire to try the experiment of buying say 400 horse-power from some street railway or lighting company; the first thing to do is to make a comparison between what would be saved by omitting the steam-making part of the plant; and what it would cost for the electrical power. A plant capable of making steam for 400 horse-power all the year through, would require three firemen, which with incidental labor, would cost probably $3,000. Allowing 1.75 pounds of coal per horse-power per hour for all purposes, which you will notice means a pretty high annual duty, the coal at $4 per ton would amount to $12,264 for the year. This added to the cost for attendance as above of $3,000 gives a total of $15,264 as the bare cost of operating the steam making plant. The fixed charges upon the boiler plant, including chimney, storage room for coal, and boiler house, etc., also the fixed charges against the cost of high class steam pumping engine capable of giving a yearly duty as above, as against an electrical pumping engine of considerably lower cost, would be apt to bring the actual cost of power used up to or over $100 per horse power per annum. Against this is the charge for electrical power if from water power, varying from $50 to $80, and if from steam power, varying from $75 to $125 per horse-power per annum.

To put it into other terms we would have a statement as follow-

ing: To the credit of the electric engine, there would be the coal, entire operating expenses, interest, taxes, insurance, repairs, and incidental expenses, including in the calculation all buildings and grounds necessary for the plant. Chargeable against the electrical pumping engine would be the operating expenses, interest, taxes, insurance, repairs, and incidental expenses, including in the calculation buildings and grounds necessary for the plant, and also charge up the electrical power required.

A glance at the above will indicate at once that the fixed charges account would show largely in favor of the electrical outfit, and in the midst of a large city, where a high service station is needed, and where the value of the necessary real estate would be an item worth considering, the electrical pumping engine removes from the field that portion of the plant which takes up by far the most of the room and which is the most troublesome to take care of. In the residence districts of some cities, where isolated service would be desirable, the power taken from an electric wire might be worth, under the circumstances, even $150 per annum per horse-power, in the complete suppression of soft coal smoke, and the curtailment of 50 per cent. of the ground covered, and the buildings necessary, where a good order of architecture would be required.

Another incidental item in favor of the electrical idea is the fact that when less power is used at any part of the day a pro rata amount corresponding to the power shut off is saved, and as there are no fixed charges against the plant when the electricity is bought from an outside company such a saving is net. Electric power contracts can no doubt be made, with a clause providing for the payment for a minimum amount, similar to water meter rates, and then a charge to be made above the minimum amount only as power is used. Also there are many steam pumping plants in operation working under a comparitively low head, so that the fixed charges and incidental expenses are apportioned to a low rate of horse-power, hence the cost of steam power for the pumping would be abnormally high. The author has in mind a pumping plant of about 200 horse-power, with a coal rate of just about 2 pounds, and where the coal and labor accounts amount to $9,870, which brings the cost per horse-power to just about $50 per annum for fuel and labor only. The fixed charges against the boiler plant, boiler house, chimney, coal storage, and coal handling outfit brings the cost of steam generating up to $85 to $90 per annum

per horse-power; other items will carry the rate over $100. The head pumped against is 110 pounds, and if the head happened to be say 60 pounds with the same attendance, as the pumping is continuous, the cost per horse-power would increase, because the fuel saved would not be in direct proportion to the decrease in power, the economy would not be quite as good, and the incidental expenses would not drop very much; but in comparing two such plants operated by electricity, the reduction in power would reflect a tangible fall in the cost of running.

Of course the question will naturally rise, that, if a certain power is to be used in pumping, and this power is to be developed by steam, why can it be delivered through the electric current at any advantage to the user? The answer is in two sections; first in reducing the pump friction to the lowest terms by moderate speed in moving the water, coupled to a high speeded steam factor of small dimensions, the electricity forming the bond between them; and second in buying the power needed in pumping, from an establishment making a business of generating the power in very large units by means of multiple expansion engines at high piston speed as compared to a slow working pumping engine; the expenses of attendance and labor being very much less per horse-power in a unit of 2,000 than in a unit of 200; it also being remembered that the larger plant admits of the use of fuel-distributing and stoking machiney, heat economizers, boiler-feeding apparatus, etc., upon a scale not admissible in the smaller plant; such facilities reducing the cost of steam and power-making to a very great extent. In the above references you will observe that very high annual economy is calculated upon; but supposing that we drop right down to the annual duty actually shown by many official reports, in which the coal consumed goes up to or over 3 pounds per horse-power per hour; we shall find that even now electrical energy could come as high as $130 per horse-power per annum with a profit to the buyer, to say nothing about incidental benefits.

With reference to water-power for generating the electric current, and by conduction, realize the energy at some distance, it has heretofore been held, previous to these days of the electrical mode of energy, that it did not pay to go very far out of the way to secure the benefits of water-power, because the near approach to the utmost economy in the steam engine reduced the cost of producing power so low that other advantages in the shape of convenience and acces-

sibility of markets, both for raw material and finished product, were of more importance than the entire question of the cost of power. But today, instead of transporting materials to the location of the water power, and carrying the finished products of manufacture to market, the power can be generated at the natural water head, and in the form of a high tension current of electrical energy, can be transmitted to any desired point within a reasonable distance, reduced in voltage if desired, and then utilized.

Probably the cost of plant, including dams, water wheels, penstocks, tail races, and other details, may carry the investment of capital per horse-power in the water power plant as high, or higher, than the necessary investment in a modern steam power plant. Even if the use of water power does cut out the fuel account, the investment in the conducting wires from the source of the water power to the place of employment represents to some extent an offset in the form of interest account, to the value of the fuel saved. From this it will appear that there are several matters to be known, before a decision can be reached as to the relative economy between steam and water power, although upon general principles the water power ought to succeed in the competition, when coal costs say $3 and upwards per ton, and when the water power is not to exceed 25 miles away from the point where the power is wanted. It must be borne in mind that the reliability of the stream furnishing the power must be unquestioned, or we may be obliged to go to the expense of an additional investment in auxiliary steam plant, which might destroy all of the seeming advantages of the cheap water power. The electrical storage battery is no doubt destined to play an important part in the using of the electrical mode of energy, as in this very question of water power, at night when factories are stopped, and the water may be largely going to waste, the generation and storage of the electrical motive force could go on through the night, until the demands for water for other power began again. Of course in dry times like the past summer where the accumulation of the water at night while the mills were at rest was only sufficient to insure a full day's power following, the storage battery could not be employed, but such seasons are exceptional, particularly as to being so widespread as in 1895.

The storage battery would apparently be a potent means of reducing the price at which power companies could afford to sell energy for

pumping purposes, as by its use the great bulk of the fixed charges could be materially reduced, providing as it does adequate means for operating the power and generating machinery at its fullest or most economical capacity 144 hours per week, and the full seven days if necessary. If the storage battery is an improvement the Germans are ahead of us, as more than three-quarters of the central power stations in that country are provided with this appliance. In public water supply, by electrical pumping machinery, the storage battery would take away the apparent risk of depending for a water supply, upon what appears to be a very slender copper wire, a consideration which would be of some weight, no doubt, to fire underwriters.

The pumping of water by means of the electrical mode of energy is very likely destined to play an important part in the future of public water supply, and the standard pump makers are already endeavoring to reconcile the differences which attended the first attempts to operate pumping machinery by electricity. Differences made apparent by the electricians' idea that any kind of a pump could be operated by attaching a motor to it, and by the pump makers' idea that any sort of a dynamo could be used in running a pump. The entire question illustrating the fact that the office of the mechanical engineer is to adjust and adapt to the conditions in hand, and objects in view, the forces of nature applied to useful effects.

DISCUSSION.

MR. BARRUS. I cordially agree with Mr. Hague that there are incidental benefits to be gained by using electrical power for pumping, and that in some situations, such as for high service pumping stations which he mentions, and, no doubt, for many other situations, the total cost of pumping water by the use of electricity is likely to be less than that due to the methods in vogue at the present time. I have in mind the case of a mill now in course of erection where the water for the industrial purposes required in the factory is to be obtained from a brook about half a mile distant. An electric plant is to be installed in the engine room of the mill, and an electric pump supplied with current from this plant is to be placed at a point near the brook. Between this arrangement and that of an independent pumping plant, with boiler, chimney, and supply of coal, and the necessity of constant attendance of an engineer to operate it, there

can be little question that electricity provides the best method for accomplishing the object. The adaptability of electricity to pumping water, it seems to me, follows the same laws as its application to the production of power for any other purpose, and it depends wholly upon the circumstances. I believe it is fairly well settled that it will not pay to transmit power electrically where the machinery to be driven is in close proximity to the generating plant, such as would be the case in an ordinary mill, or in ordinary pumping stations. I do not mean by this statement that it would not pay to transmit power by electricity in such a situation, whether it be in a mill or in a pumping plant, provided the current was obtained from a large central electric plant at a price far below the cost of producing the current in an isolated plant, but the statement applies simply to the generation of the current by an independent plant which is to be erected for the purpose in hand. I think any engineer at all familiar with the subject will bear out this assertion.

As to the general subject, and the relative economy of steam consumed in the two processes, it seems to me that there is some ground for criticising Mr. Hague's calculations. In his computations he makes out that the steam consumed by the electric pump per horse-power per hour of water delivered is 15.3 lbs., as against a consumption of 16 lbs. in the case of the mechanically driven pump. One of the elements upon which this comparison is based is the assumption that in the electric plant the steam used per indicated horse-power of the driving engine per hour is 11 lbs., while in the mechanically driven pump the consumption is put down at 14 lbs. I do not think I am wrong in saying that pumping engines have realized as high economy in steam consumption as any engine used in the production of mechanical power in spite of the fact that the pumping engine operates at relatively slow speed. I have in my own work obtained as high economy from a pumping engine running at 20 revolutions per minute, as from a triple expansion mill engine of large size making 70 revolutions per minute, and there is good ground for the belief that the published records obtained by other parties on this subject are reliable. These show the same fact, namely, that the power developed in the steam cylinder of a pumping engine can be produced with as small a consumption of steam as that produced in the steam cylinder of an engine driving an electric generator. I fail to understand, therefore, what ground there is in this paper for

assuming any such difference of economy in favor of the electrical pump as that stated. I see no reason why there should not be an equality in the quantities assumed, in which case, according to my calculations, the cost of electrical power expressed in terms of steam per pump horse-power per hour would be some 20 per cent. more than that produced by the mechanically driven pump.

It is of little consequence, however, whether these assumptions and calculations are correct or not, for the question of the use of electricity for pumping in any individual case will depend altogether upon the local conditions, as is well stated in the paper. There is no doubt that there is a wide field for the application of electricity in water works service. It is well to bear in mind that the time is probably coming when towns and cities will not only own and operate their own water works to a larger extent than is done at present, but they will also come into possession of the electric plants now in use for lighting purposes, or install their own for the necessary work of the town or city. It is easy to foresee that when this condition of things is brought about, and especially where new plants are to be installed for these two purposes, that many cases will arise where it will seem expedient to provide a central station of sufficient capacity to generate electricity, not only for the lighting, but for pumping water, and establish at the point of water supply an electric pumping plant in place of a complete steam plant, thereby securing the benefits which attend the generation of steam and the production of power at a single station.

MR. HAZEN. I have listened to the paper of Mr. Hague with great interest, and to the discussion of it by Mr. Barrus. There seems to be a sort of fascination in the word "electric." We hear of electric medicines, and of electrical processes for doing this or that in which in reality there is no electricity except in the name itself. But here seems to be a case where electricity has a new use, or at least a new application, and I think we should all like to hear from Mr. Dean himself as to what he thinks of the process mentioned in the paper which he has read, that is as to its adaptability, practicability, etc.

MR. DEAN. Mr. Hague lays himself open to rather severe criticism in some of the assumptions which he has made in his paper, and which, I think, if properly stated would lead to different con-

clusions. I think Mr. Barrus has stated the matter pretty nearly right. There are a great many cases, of course, where it may be advisable to use electricity, but I think that the figures which Mr. Hague has given are likely to mislead and I should be very sorry to have them go unchallenged.

Of course I am rather more likely to notice the steam features of his paper than the electrical ones. As to the adaptability of electricity, it can be transmitted from one place to another without any difficulty, and you can make it as economical as you choose, and you can make it pump water. And I think any man, if he had a case at hand, at a high service pumping station, for instance, could very quickly come to a conclusion as to whether he had better drive pumps by electricity or establish an independent steam pump. As Mr. Hague says, many fixed charges would be very much reduced by the substitution of electricity for direct steam.

I am a little puzzled at Mr. Hague's paper, because in some places he seems to give estimates unduly favorable to the steam pumping engine, and at other times quite the opposite. He speaks of the efficiencies of pumping engines as being about 87 per cent. of the power developed at the steam end, while there are a great many cases in pumping engines of the kind that Mr. Hague has been so closely connected with in late years, and also in others that differ from them very much, in which the efficiency is above 87 per cent. For instance, at Lowell the high duty Worthington pumping engine gave an efficiency of 97 per cent. That engine was tested by Mr. Barrus, and the test was sufficiently long to give a virtual duplication of results, so that nobody could reasonably doubt it. Then, at the Manchester water works I obtained an efficiency of 94 per cent. from the same kind of engine. At Louisville, the fly-wheel Leavitt engine, which is very heavy, gave an efficiency of 93, and at Newton the Blake engine gave 92. The old Morris engine at Lowell, which I have tested twice within two years, has given 97.36 and 97.51 per cent., and the celebrated Allis engine at Milwaukee gave 91 per cent. efficiency.

At the steam end of the pumping engine Mr. Hague takes the steam consumption at 14 pounds of steam per horse-power per hour, and 16 pounds per pump horse-power per hour; and he takes the high speed engine, with which he proposes to drive his electrical

generator, as using 11 pounds of steam per horse-power per hour, and claims that in consequence of the high speed of the possible engine driving the electric apparatus, the great economy of 11 pounds of steam is attained.

It seems to me that there is nothing more delusive than this speed idea, because it happens that about all of our economical consumptions of steam in steam engines are obtained from pumping engines. And while quick reciprocation gives less time for condensation to take place, it does seem as if the desire of a steam engine to condense steam is greater than the possibility of the steam to overtake it. I believe I am right in saying that there are not over two engines in the world that use as little as 11 pounds of steam per horse-power per hour, and possibly only one. It may be that the Leavitt pumping engine at Chestnut Hill in Boston will show as low as 11 pounds of steam per horse-power per hour when the engine is perfectly broken in, and the steam working parts have become smoothed down and everything is perfectly tight.

It has been reported in various papers that a small engine in Germany, known as the Schmidt motor, tested by Prof. Schröter, of Munich,* a very reliable man, has used as little as 10.17 pounds. But that engine used steam which was superheated to nearly 300 degrees, and, as you know the great enemy of economy is steam condensation, this great superheating of the steam prevented condensation from taking place. But the persistency of the tendency of steam to condense is illustrated well in this case, for when the steam left the cylinder of the engine it was ordinary steam, and this great superheat had left it. Superheated steam is the hope of the future in economy, but it is something which vanishes with great rapidity.

There is only one engine, so far as I know, which seems to be benefitted by high speed, and it is difficult to determine in that case whether it is the high speed, or some of its many other admirable features, which account for its economy. I refer to the Willans engine. It is an English engine, but has now been taken up in this country by the M. C. Bullock Manufacturing Co. of Chicago.

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*See *Engineering*, Vol. LIX., 1895.

Then, coming to the pump end of the electrical apparatus, Mr Hague takes the efficiency of that as 89 per cent., that is to say taking the efficiency of motor and engine together, he gives it as 89 per cent. That is slightly higher than he takes the efficiency of the pumping engine. But the connection between the motor and the pump would very likely be through gears, and of course the efficiency of gears is low, and it is rather difficult for me to see how he can take the efficiency of such a combination higher than he takes that of the ordinary pumping engine.

Now, by starting with an extremely economical and hypothetical engine, for such a one does not now exist, Mr. Hague finally comes to a consumption with an electrical plant of 15.3 pounds of steam per pump horse-power; whereas, if he had started with a probable and contemporaneous engine, using say 13 pounds, he would have arrived at about 18 pounds at the pump end. And, coming back again to the matter of steam consumption, while I stated the efficiency of various engines, I will now state their steam consumption per pump horse-power: Louisville, 13.05; Newton, 15.25; Lowell, Worthington, 16.58; Manchester, Worthington, 19.76; and the Milwaukee, Allis, 13, the Allis being the lowest.

There is another factor to be considered when it is proposed to buy electricity from a street railway or from a lighting plant. If such a company were to sell electricity to a city for pumping they would have an advantage, if they chose to profit by it, of having a steady power, and therefore the engine which they used might very well be proportioned to do its work at the most economical rate, and therefore the city would be entitled to the lowest price per horse-power per hour. But street railway plants are very wasteful indeed, because the power is everything; it is all the way from zero to the maximum. And so at Milwaukee, even with a triple-expansion engine, which should have used as low as 13 pounds of steam per horse-power per hour, the fact is they use over 18. Now, if you can make a street railway company distinguish between the economy of your part of the plant and that of their own part, you will do better than I think you can. I think they would charge you as high a rate as they charge for any of the rest of it. And they are not content with small profits. I recently had a case in which a street railway company wanted to sell power for a certain purpose, and I was asked to obtain for them the cost of the power, and I

then added what I thought ought to be a proper, or at least—yes, a proper profit; I added 15 per cent. as the profit to them, and they were astonished at the lowness of it, and I judged from their conversation that they wanted 100 per cent. profit instead of 15.

It seems to me that the suggestion that Mr. Leavitt made when he read his paper before this association a year ago last summer, that at the pumping station there is to be in the future an electrical plant for the various purposes for which a city needs it, is the thing that is coming to the help of the city wherever it needs a small power at a distance. The pumping plant and the electrical plant for lighting the city will very likely be in the same place, and in that case the fixed charges could be very considerably reduced.

In regard to water power, Mr. Hague mentions a difficulty. It is very seldom that a water power is worth having, for the reason that it is very unsteady. Sometimes there isn't water enough, and at other times there is too much, so that the power is inadequate, and that means a spare steam plant, with all that goes on with it for fixed charges. And then again there comes the reduced efficiency of waterwheels by getting all sorts of things in them, and anchor ice, and the employment of a special man to fish out the anchor ice, leaves, etc.

The depreciation of an electrical pumping plant is probably greater, I have no doubt it is greater than that of a steam plant—perhaps 7 or 8 per cent. depreciation instead of say about 4 for a pumping engine.

Finally, it is, I should say, perfectly practicable to use electricity in this way, and whenever a case comes up I have no doubt that the engineer in charge will come to proper conclusions in regard to it. You can do pretty much anything with electricity, but it is something that is very much over-rated. It is being quacked about as being a cure for everything. We hear it said that electric locomotives are going to double the speed of steam locomotives. But the people who talk that way have no idea of the limitations of speed, they don't know how train resistance increases, and what they say is generally worthless. There seems to be in connection with the electric companies a bureau for the dissimination of useless knowledge, which appears in all the newspapers. (Laughter and applause.)

MR. CRANDALL. I would like to ask if 5 per cent., the amount

which Mr. Hague mentions as the loss in the conductor, isn't very much less than is ordinarily encountered, on account of the cost of a conductor which would effect only that amount of loss.

MR. DEAN. I feel I am assuming a great deal in attempting to discuss electrical matters, as I know probably as little about electricity as any one here present. I thought Mr. Hague had taken the electrical losses as very small, and beyond that I cannot say anything.

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